Elk Hills Power

April 30, 2015

Ms. Michele Dermer
U.S. Environmental Protection Agency
Ground Water Office (WTR-9)
75 Hawthorne Street
San Francisco, CA 94105

Subject: Elk Hills Power, LLC – Aquifer Exemption Application

Dear Ms. Dermer:

Elk Hills Power, LLC (EHP) is submitting for your consideration an Aquifer Exemption application for the 1B and 2B sections of the Elk Hills oilfield. The aquifer exemption application will support the permitting, construction, and operation of three Class I Underground Injection Control (UIC) wells. The Class I UIC wells will be utilized to dispose of non-hazardous industrial fluids produced during the operation of EHP's electrical generation units.

Should you have any questions of the submittal, please feel free to contact me at (661) 765-1801 or Mr. Sonnie Pineda, Sr. Environmental Advisor, at (661) 765-1805.

Sincerely,

Robert Bond
EHP Team Leader

Attachments:
Aquifer Exemption Application (2 copies)

Cc:
C. Jones - ltr
M. Nelson - ltr
J. Hegeman - ltr
D. Nelson - ltr
R. Garcia - ltr
D. Albright, EPA – ltr
L. McWhirter, EPA – print copy
J. Walker, EPA Consultant – print copy
EHP File – 01Annual\UIC\2015

Elk Hills Power

ENVIRONMENTAL PROTECTION AGENCY

AQUIFER EXEMPTION APPLICATION

FOR CLASS I NON-HAZARDOUS UIC WELLS

SUBMITTED BY ELK HILLS POWER, LLC

TUPMAN, CALIFORNIA

PREPARED BY:

SAN JOAQUIN ENERGY CONSULTANTS, INC.

APRIL 29, 2015

Elk Hills Power, LLC
Aquifer Exemption Application
Class I Non-Hazardous Injection Wells

A. Regulatory Background and Purpose

An aquifer or a portion thereof which meets the criteria for an "underground source of drinking water" in § 146.3 may be determined to be an "exempted aquifer". The aquifer exemption criteria at 146.4 must be met as follows:

> -Class I-V wells must meet **criteria 146.4(a) and 146.4(b)(l)**; or **146.4(a)** and **146.4(b)(2**); or **146.4(a)** and **146.4(b)(3);** or **146.4(a)** and **146.4(b)(4);** or **146.4(a)** and **146.4(c).**
>
> -Class VI wells must meet the criteria **146.4(d).**

Regardless of the AE request or the type of injection activit y, in all cases, first and foremost a demonstration that the aquifer or portion thereof does not currently serve as a source of drinking water is the required first step in the process.

B. General Information

Is the aquifer exemption: Substantial___ Non-Substantial: √

Describe basis for substantial/non-substantial determination:

The total dissolved solids (TDS) concentrations in the Lower Tulare member of the Tulare Formation in the area of review are greater than 3,000 mg/l , which qualifies it as a non-substantial aquifer exemption . Detailed information on the TDS content of Lower Tulare groundwater is provided in the discussion of the TDS content of the aquifer on pages 4 through 6, the "TDS" section on page 10 and in the discussion for meeting the criteria of 40 Code of Federal Regulations (CFR) §146.4(c) on pages 19 through 22 of this application.

Is the aquifer exemption complex? (Existence of drinking water wells, populated area…)

No. There are no known drinking water wells within the area of review (Attachment 1 through Attachment 3). The area is sparsely populated and has had low to negative population growth rates from 2010 to 2014(Attachment 4). The nearest town is Valley Acres, which islocated about five miles to the south and has a population of about 532.

Any anticipated issues associated with EPA approval or disapproval of the AE request Y/N

Yes. The Elk Hills Power Plant (EHPP) is a 550-megawatt, natural gas-fired cogeneration facility. The facility consists of two combustion turbine generators, two heat recovery steam generators with duct burners , and one steam turbine. The facility generates enough electricity to supply

approximately 500,000 homes in Kern County area. The EHPP entered commercial operation on July 23, 2003, and is owned by California Resources Corporation (CRC).

The EHPP uses a cooling tower to supply water for cooling the plant equipment. The facility currently sends the cooling tower's required blowdown stream, which is non-hazardous, to Class I Underground Injection Control (UIC) wells for disposal. These injection wells are critical to EHPP operations. If the facility was unable to dispose of the cooling tower blowdown water, a plant shutdown would have to be initiated within no more than a few days.

In 2013, the facility became a cogeneration facility, delivering steam for the oil and gas production processes and power directly to the oil and gas field. If the EHPP was not operating, there would be no steam and power available from the plant, which would negatively impact the oil and gas production operations in the Elk Hills field.

The EHPP is a Federal Energy Regulatory Commission-certified Qualifying Facility that generated more than 3.9 gigawatt hours (GWh) of power in 2014, helping meet the electrical supply needs and supporting California's energy grid.

The facility was a sizeable investment of hundreds of millions of dollars and pays millions each year in state and local property taxes for the benefit of the State of California and the surrounding communities. EHPP's 23 employees as well as numerous companies and contractors who supply goods and services to the plant also live in the local area and are economically benefitted by the operation of the facility.

In the event the plant was unable to run, there would be negative impacts to the electrical grid, oil and gas production, and the state and local economies.

Name of owner/operator: Elk Hills Power, LLC (EHP)

Well/Project Name: 15-1B, 26-EHP-WD-1B, 77-EHP-WD-2B, and 47-EPH-WD-2B.

Well Class: Class I UIC Non-Hazardous

Purpose of injection: Other **(mineral mining/oil and gas/other)**

The purpose of the proposed EHP injection wells is to dispose of non-hazardous industrial fluids produced during the operation of an electrical power generating plant. The types of fluids to be injected are limited to turbine wash wastewater, cooling tower blowdown wastewater, plant area wash wastewater, demineralizer system wastewater and resins regeneration drains, plant and equipment drains wastewater, filter backwash wastewater, water treatment wastewater, and non-oil contaminated storm runoff wastewater.

Where is the proposed aquifer exemption located?

Township, Section, Range, Quarter Section or other method used to identify the area:

Portions of the Sections 1 and 2, Township (T) 31 South (S)/Range (R) 23 East (E), Mount Diablo Base & Meridian (MDB&M), referred to in this application as the 1B/2B area (Attachment 1).

Latitude and longitude information:

WELL	TYPE	LATITUDE	LONGITUDE
15-1B	Conversion	35.259365701	-119.464828088
26-EHP-WD-1B	New	35.257915265	-119.461807495
77-EHP-WD-2B	New	35.256083031	-119.470722429
47-EHP-WD-2B	New	35.255485818	-119.476058086

County: Kern

City: Unincorporated

State: California

Add information about distance to nearest Town, County:

The proposed EHPP aquifer exemption area is located in a remote, unincorporated area of Kern County. The nearest town is Valley Acres, which lies about five miles south of the proposed EHPP wells. Distances to nearby towns are provided in Attachment 4.

Name of aquifer or portion of aquifer to be exempted:

The Lower Tulare member of the Tulare Formation from the base of the Amnicola Claystone to the top of the San Joaquin Formation, referred to in this application as the Lower Tulare (Attachment 5).

Areal extent of the area proposed for exemption:

The proposed EHP aquifer exemption area consists of a fixed distance of 1,500 feet around each of the four proposed EHP well locations, as shown in by the gray shaded areas in Attachment 1. The proposed aquifer exemption area lies within the sections in which the State Water Resources Control Board (SWRCB) concurred with an aquifer exemption request for Class II UIC operations by the former Occidental of Elk Hills, Inc., (OEHI), now CRC . This aquifer exemption was requested for the entire saturated zone of the Upper Tulare member of the Tulare Formation, referred to in this application as the Upper Tulare, and both the unsaturated and saturated zones of the Lower Tulare (Attachment 6). No Class II UIC operations in the Lower Tulare are planned for the 1B/2B area at this time.

Depth and thickness of the aquifer:

Table 1 summarizes the depths and the thickness of the Lower Tulare at the proposed EHP well locations. The estimated depth to the top of the Lower Tulare ranges from 1,153 to 1,321 feet. Its estimated gross and net thicknesses in the area of the four proposed wells vary from 486 to 565 feet and 327 to 402 feet, respectively.

The depth and thickness of the proposed injection zone within the area of reviewalso are shown on cross-sections through the proposed EHP well locations (Attachment 7), structure contour maps of the top and bottom of the proposed injection zone (Attachment 8 and Attachment 9, respectively), a structure contour map of the base of the unsaturated zone in the Lower Tulare (Attachment 10), isochore maps of gross and net Lower Tulare sand thickness (Attachment 11 and Attachment 12, respectively), and isochore maps of the thickness of the saturated and unsaturated Lower Tulare (Attachment 13 and Attachment 14, respectively). All major stratigraphic markers, particularly the bases of the Lower Tulare and the Amnicola Claystone, are readily identifiable and exhibit excellent lateral continuity.

Table 1: Summary of Lower Tulare Geologic Data

Well	Lower Tulare Depth (feet)	Lower Tulare Thickness (feet)	Net Sand Lower Tulare[1] (feet)
15-1B (conversion)	1,212 (from log)	544	402 (from baseline of -25 mV)
26-EHP-WD-1B	1,153,(projected)	565	380 (assuming 67.2% sand)
77-EHP-WD-2B	1,254 (projected)	517	347 (assuming 67.2% sand)
47-EHP-WD-2B	1,321 (projected)	486	327 (assuming 67.2% sand)
Average:	**1,235**	**528**	**364**

Discuss the total dissolved solid (TDS) content of the aquifer, including the TDS at the top and bottom of the exempted zone, and the locations and depths of all fluids samples taken.

The TDS content of groundwater in the Lower Tulare is based on laboratory analyses from two nearby wells: the 82-2B[2] and the 48-9G[3] (Attachment 1[4]; Attachment 15; Table 2). Groundwater sampling procedures are provided in Attachment 16.

The groundwater sample from well 82-2B was collected from a sand interval in the Lower Tulare, which was perforated from 990 to 1,046 feet, or about 150 feet above the base of the Tulare

[1] Discussion of the method of net sand estimation in the Lower Tulare is included inAttachment 12.

[2] B refers to T31S/R23E

[3] G refers to T31S/R24E

[4] Locations of 82-2B and 48-9G are shown as blue circles on the index mapin Attachment 1.

Formation. The TDS concentration in this interval is 20,000 mg/l. Because its TDS concentration exceeds 10,000 mg/l, Lower Tulare groundwater in this locality is, by definition, not a protected Underground Source of Drinking Water (USDW)[5].

Table 2: Summary of Lower Tulare Groundwater Analyses

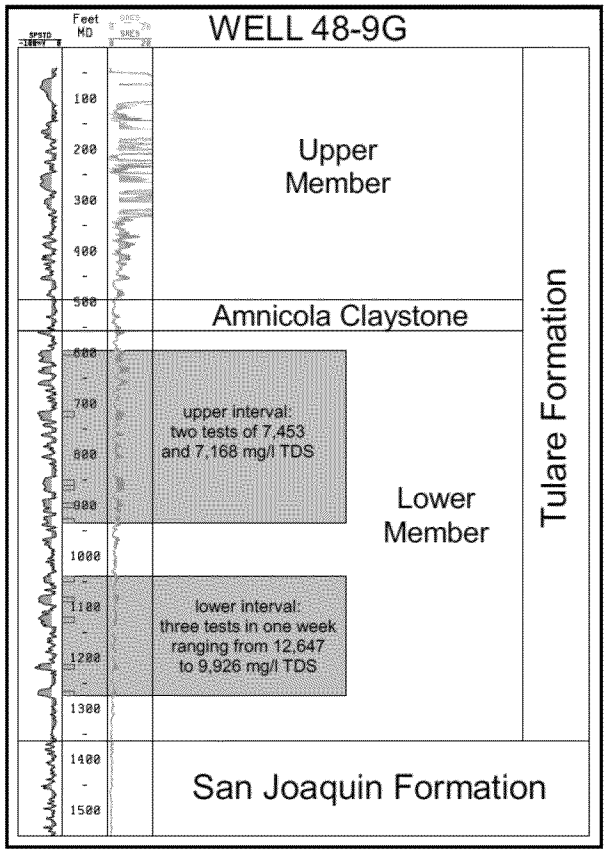
Well No.	Depth (feet)	TDS (mg/l)	Protected USDW?	Name	Top/Bottom of Zone
82-2B	990-1,046	20,000	No	Lower Tulare	Near bottom
48-9G	595-935	7,168	Yes	Lower Tulare	Near top
48-9G	595-935	7,453	Yes	Lower Tulare	Near top
48-9G	--	9,926	Yes	Lower Tulare	Near bottom
48-9G	1,040-1,265	10,062	No	Lower Tulare	Near bottom
48-9G	1,040-1,275	12,647	No	Lower Tulare	Near bottom

Groundwater analyses from the 48-9G had TDS concentrations in the Lower Tulare ranging from 7,168 to 12,647 mg/l (Table 2; Attachment 15). Two Lower Tulare intervals were tested: 595 to 935 feet and 1,040 to 1,275 feet (Figure 1). The upper interval, with groundwater analyses of 7,168 to 7,453 mg/l TDS, represents the TDS concentrations near the top of the Lower Tulare. The deeper interval, with TDS concentrations ranging from 9,926 to 12,647 mg/l, characterizes TDS near the bottom of the zone. Where TDS concentrations in the 48-9G exceed 10,000 mg/l, groundwater is not a protected USDW by definition.

TDS concentrations in Lower Tulare groundwater show a general trend of increasing with depth. It is believed that this results from its proximity to the underlying marine San Joaquin Formation as well as other deeper, marine rocks that contain connate water having naturally high salinity. Salinity calculations for Lower Tulare intervals in other nearby wells are in generally good agreement with measured TDS concentrations. These are discussed in more detail in the "TDS" section on page 10 of this application and under the discussion for meeting the criteria of 40 CFR §146.4(c) on pages 19 through 22.

[5] A USDW is defined as an aquifer or portion of an aquifer that supplies any public water system or that contains a sufficient quantity of groundwater to supply a public water system, and currently supplies drinking water for human consumption, or that contains fewer than 10,000 mg/l total dissolved solids and is not an exempted aquifer.

Figure 1: Measured TDS Concentrations in the Lower Tulare in the 48-9G Well



C. Regulatory Criteria

An aquifer or a portion thereof may be determined to be an exempted aquifer for Class I -V wells if it meets the criteria in paragraphs (a) -(c) below. Other than EPA approved aquifer exemption expansions that meet the criteria set forth in 146.4(d), new aquifer exemptions for Class VI wells shall not be issued.

146.4: (√) (a) ***Not currently used as a drinking water source and:***

( ) **(b)(1)** It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class I or Class II operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible; or

( ) **(b)(2)** It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical; or

( ) **(b)(3)** It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or

( ) **(b)(4)** It is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

(√) **(c) TDS is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.**

( ) **(d)** *The areal extent of an aquifer exemption for a Class II enhanced oil recovery or enhanced gas recovery well may be expanded for the exclusive purpose of Class VI injection for geologic sequestration under § 144.7(d) if it does not currently serve as a source of drinking water; and the TDS is more than 3,000 mg/l and less than 10,000 mg/l; and it is not reasonably expected to supply a public water system.*

1. **Demonstration that the aquifer or portion thereof does not currently serve as a source of drinking water per 146.4(a)**

Describe the proposed exempted area and how it was determined:

The area of review for the Tulare aquifer exemption was based on both injectate front and pressure front calculations, as discussed in the following two sections.

Injectate Front Calculations: The injectate front calculations are based on the volumetric method of Warner and Lehr (1981). This is a standard, industry-accepted method that assumes the injectate will uniformly occupy an expanding cylinder, move away from the well with horizontal flow, and have a reasonable amount of dispersion. The Warner and Lehr methodology is more appropriate for the injectate front calculations than the Theis method, which assumes that there is a vertical pathway for the injectate to reach the USDW. It will be demonstrated later in this application that the Amnicola Claystone is an effective overlying confining zone and will not provide such a migration pathway. The Warner and Lehr (1981) methodology will be relied upon only as a first order approximation of the injectate front.

- Porosity: 35.4% (Attachment 17)
- Net sand: 364 feet (Table 1; Attachment 12)
- Projected plant lifetime of 20 years
- Four cases were run for injection rates: 1) the current injection rate of 5,982 bbls water per day (BWPD) using one well; 2) the current injection rate using two wells, or 2,991 BWPD per well, 3) the permitted injection rate of 14,964 BWPD using one well, and 4) the permitted rate using two injection wells, or 7,482 BWPD per well (Table 3). The current injection rate was based on the two-year plant average injection rate from March 1, 2013, to February 28, 2015. The permitted injection rate was based on the design capacity of the

plant. The most likely case is considered to be the current injection rate using two wells because two wells are now being used for EHPP injection needs, and it is expected that two wells will continue to be used in future operations.

Table 3: Injectate Front Calculations

INJECTATE FRONT LOCATIONS IN THE LOWER TULARE
BASED ON WARNER & LEHR EQUATIONS
PROPOSED AREA OF REVIEW: 1,500 FEET FIXED DISTANCE

Current Q, 1 Well (BPD):	5,982	Net H (ft):	364
Current Q, 2 Wells (BPD per well):	2,991	Porosity:	35.4%
Permitted Q, 1 Well (BPD):	14,964		
Permitted Q, 2 Wells (BPD per well):	7,482		

Case	Years	Injectate Radius without Dispersion, Ft	Injectate Radius with Dispersion, Ft
Current Rate, 1 Well	20	778	889
Current Rate, 2 Wells	20	550	644
Permitted Rate, 1 Well	20	1,231	1,371
Permitted Rate, 2 Wells	20	870	988

Assuming the current forecast rate is maintained, the injectate front with dispersion using one and two wells would be 889 and 644 feet from the wellhead, respectively. Even in the improbable case of sustaining the permitted injection rate using one well over 20 years, the injectate front with dispersion would be 1,371 feet from the wellhead. The injectate front for two wells at the permitted rate would be 988 feet with dispersion.

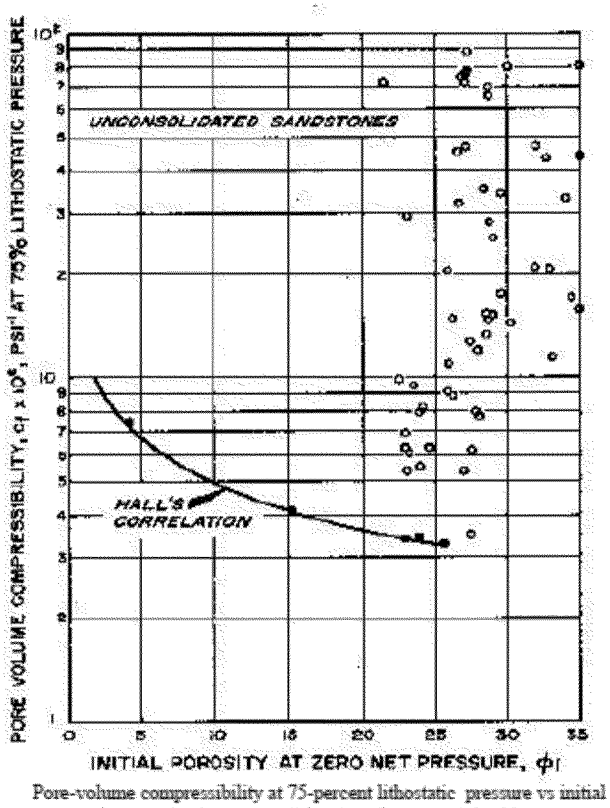
A 1,500-foot area of review around each EHP well location is proposed based on the injectate front calculation for the permitted rate into one well. This is believed to be reasonable because the permitted rate would represent the upper end of all injection rate scenarios. Although it is unlikely to be sustained in a single well for 20 years and more than 2.5 times the current injection rate, using the permitted rate allows additional area around the wells to compensate for the first order approximation of the injectate front. For the most likely case of the current rate using two wells, the area of the injectate front is only 18% of the proposed 1,500-foot area of review.

Although a 1,500-foot area of review is supported by the injectate front calculations, the water well survey done for this application was expanded to a distance of at least three miles from the proposed EHP well locations and still identified no water wells within this vicinity (Attachment 3).

Pressure Front Calculations: The pressure front calculations for the area of review also were based on Warner and Lehr (1981). These calculations predict increases in pressure within the proposed injection zone at specific distances and times for a given injection rate and assume that the injection system has reached steady state. The porosity, net sand thickness, projected plant

lifetime, and injection rates were the same as those used in the injectate front calculations, except that only the cases of the current and permitted injection rates using one well were run. An average permeability of 1,862 md was based on analyses of Lower Tulare sands in conventional cores, which will be discussed in more detail on page 12 of this application. An injectate viscosity of 1 centipoise and a reservoir compressibility of 3.4 x 10^{-6} also were used in the calculations. Because the Lower Tulare is an unconsolidated sandstone with high permeability, this reservoir compressibility was considered appropriate because it is the lowest value of compressibility in a cross-plot by Newman (1973) for Hall's Correlation for consolidated sandstones (Figure 2) (MHA Petroleum Consultants, 2012).

Figure 2: Pore Volume Compressibilities for Unconsolidated Sandstones



Pore-volume compressibility at 75-percent lithostatic pressure vs initial sample porosity for unconsolidated sandstones. After Newman.

Table 4 indicates the increases in formation pressure at various distances from the injection wells after 20 years of injection. Pressure increases at a distance of one foot from the wellhead would be 16.08 psi for the current injection rate and 40.22 psi for the sustained, permitted injection rate. These relatively low pressure increases, combined with a confining zone that is about 60 feet thick in the area of the proposed EHPP wells, make it unlikely that injectate would migrate above the top of the proposed Lower Tulare injection zone.

Table 4: Pressure Front Calculations

PRESSURE FRONT CALCULATIONS AFTER 20 YEARS OF INJECTION					
Net H (ft):	364.0	Q (BPD):	5,982	Q (BPD):	14,964
t (years):	20	Porosity:	35.4%	Porosity:	35.4%
Ct:	3.4E-06	Uw (cp):	1	Uw (cp):	1
		k (md):	1,862	k (md):	1,862
		Pressure Increase in Tulare Zone			
	Distance from Injection Wells, ft	Current Rate		Permitted Rate	
	1		16.08		40.22
	10		13.21		33.04
	100		10.34		25.86
	250		9.19		23.00
	500		8.33		20.84
	750		7.83		19.58
	1,000		7.47		18.68
	1,320		7.12		17.81
	1,500		6.96		17.41
	2,000		6.60		16.52
	2,500		6.32		15.82
	2,640		6.26		15.65
	3,000		6.10		15.25
Calculations based on Warner & Lehr; eqn 3.9a					
Delta P = {(162.6*Q*Uw)/(k*h)}*{log(k*t)/(phi*Uw*Ct*r^2)-3.23}					
Where:	Delta P = psi reservoir pressure change at raidus r (ft) and time t (years)				
	Q = injection rate, BPD				
	Uw = injectate viscosity, centipoise				
	k = reservoir permeability				
	h = net thickness, ft				
	t = injection time, years				
	phi = reservoir porosity, %.				
	Ct = reservoir compressibility. Psi^-1				
	r = radius of interest, ft				

TDS:

TDS concentrations were based on groundwater samples in the 82-2B and 48-9G wells , as previously discussed on pages 4 through 6 of this application. Both wells are completed in the Lower Tulare and have an overall TDS range of 7,168 to 20,000 mg/l (Attachment 15).

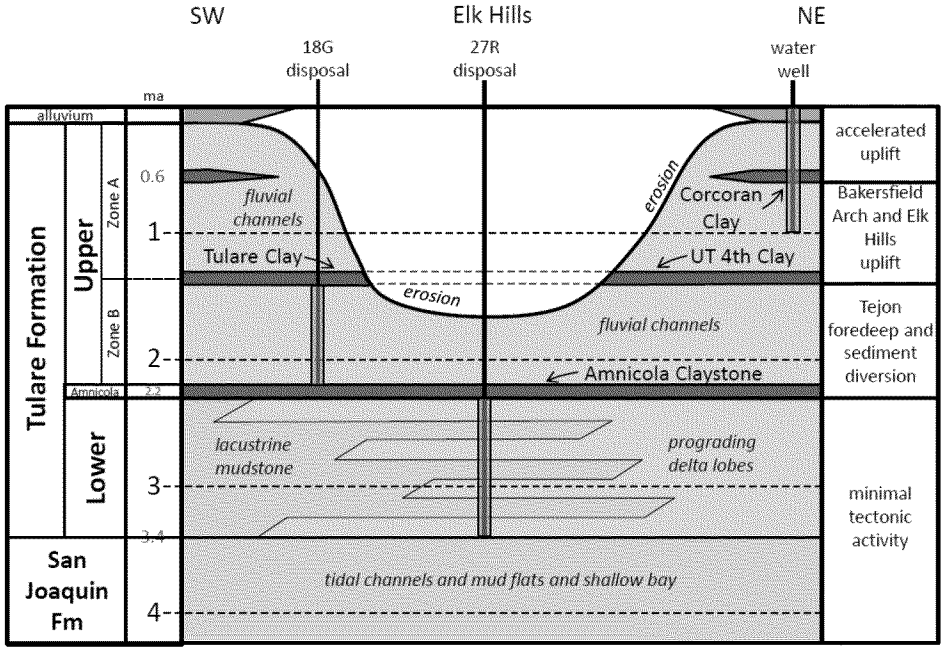
Top: 7,168 mg/l based on the minimum TDS concentration inLower Tulare groundwater analyses from the upper tested interval in the 48-9G (Attachment 15; Table 2).

Bottom: 20,000 mg/l based on Tulare groundwater analyses from the 82-2B, sampled near the base of the Lower Tulare (Attachment 15; Table 2; Figure 1).

Lithology:

The lithology of the Tulare Formation is provided according to the informal Tulare stratigraphic names used in the Elk Hills area, which are shown on Figure 3. The Lower Tulare is the interval between the top of the underlying San Joaquin Formation and base of the Amnicola Claystone (Attachment 5). Between the top of the Amnicola Claystone and the Corcoran Clay is a thick interval informally named the Upper Tulare. Because of its thickness and stratigraphic variability, the Upper Tulare is further divided into the shallower A Zone and the deeper B Zone. On the south flank of Elk Hills, the Tulare Clay is present between the A and B Zones. The E Clay, which is equivalent to the Corcoran Clay, and undifferentiated Tulare/Alluvium overlie the Upper Tulare A Zone in some areas to the north and south of Elk Hills (Croft, 1972) but have been eroded in the 1B/2B area (Attachment 7). Outcrops of the Tulare Formation at Elk Hills are of the Upper Tulare B Zone with only a narrow fringe of A Zone present at the farther down-slope edges of the Hills.

Figure 3: Tulare Formation chronostratigraphy in the Elk Hills area.



Modified from Miller, 1999

According to Milliken (1992), the lithology of the Tulare Formation in the area of the south flank of Elk Hills is as follows:

- Clays in the Tulare Formation are hard, dense, and waxy and described as chocolate brown, olive drab, tan, or buff in color. There are two main clay units in the Tulare Formation in the area: the Amnicola Claystone and the Upper Tulare Clay (Figure 3). The Amnicola Claystone

is typically a very clean clay. The Upper Tulare Clay consists of a thick clay with interbedded fine- to very coarse-grained sands and sandy gravels.

- Tulare siltstones typically are unconsolidated to moderately cemented and range from clean to clayey. The color of the siltstones varies from tan to buff or brown.
- Sands are "…commonly very clean, well-sorted, and contain minor gravel." They usually are light gray and interbedded with gravels.
- Tulare gravel beds in outcrop typically have distinctive clast sizes, compositions, matrix sizes, and color that allow them to be correlated. Clasts in the gravels, which can be up to 12 inches in size, appear to have been sourced from batholithic and metamorphic roof pendant terranes. There also are "boulder beds", which are believed to have been deposited by mudflows, and gravels with smaller siliceous clasts sourced from the Temblor Range.

Permeability:

Horizontal permeability = 1,862 md based on the average of sands cored in the 1CH-27R[6], 46WD-76, and 36-30R wells[7] (Attachment 17, page 2).

Vertical permeability = 1,568 md based on the average of sands cored in the 1CH-27R well (Attachment 17, page 1).

Porosity:

Porosity = 35.4% based on the average of porosities of sands cored in the 1CH -27R, 46WD-76, and 36-30R wells (Attachment 17, page 2).

Groundwater flow direction:

Site-specific Information on Lower Tulare groundwater elevations or flow direction was not available in the 1B/2B area from CRC data and was not shown on regional groundwater maps published by either the Department of Water Resources (DWR) (2006) or the Kern County Water Agency (KCWA) (2008). The direction of groundwater flow in the Lower Tulare is assumed to be south-southwesterly based on the local topography and dip of the base of the Lower Tulare in the 1B/2B area (Attachment 1; Attachment 9).

Upper and lower confining zone(s) and description of vertical confinement from USDWs:

USDWs, Aquifer Exemptions, and Non-Protected Groundwater in the Area of Review: The uppermost groundwater in the northern part of the 1B/2B area lies within the Lower Tulare (Attachment 7 through Attachment 7e). In the southern part of the 1B/2B area, the uppermost occurrence of groundwater is in the Upper Tulare (Attachment 7a; Attachment 7b; (Attachment

[6] R refers to T30S/R23E.

[7] The 1CH-27R, 46WD-76, and 36-30R wells are the only wells in the Elk Hills field which have Tulare core data.

7e). Upper Tulare groundwater was characterized based on laboratory analyses from water source wells on the south flank of the Elk Hills field (San Joaquin Energy Consultants, 2014). It had initial TDS concentrations ranging from 4,150 to 8,720 mg/l, technically qualifying it as a USDW[8]. There are no known occurrences of USDWs above the Upper Tulare in the 1B/2B area because all shallower formations have been eroded.

There are no known protected USDWs within or below the underlying San Joaquin Formation, which is of marine origin and produces oil and gas in areas of the Elk Hills field. The TDS concentrations of the Mya and Scalez zones of the San Joaquin Formation are 37,300 mg/l and 33,400 mg/l, respectively (Department of Conservation, 1998). Groundwater analyses from nearby wells 476-27R and the 474-32S[9], which were completed in the San Joaquin Formation, had TDS concentrations that ranged from 11,562 to 24,427 mg/l (Attachment 18).

Non-protected groundwater and aquifer exemptions exist directly to the north and south of the 1B/2B area, respectively (Attachment 1). To the north of the Section 1B, the SWRCB reviewed and concurred with a demonstration by the former OEHI, now CRC, that protected water is absent in 36R (Attachment 19). Two to three miles south of the 1B/2B area, the Tulare Formation within the administrative limits of the Buena Vista field has an aquifer exemption as defined in the 1982 Memorandum of Agreement (MOA) between the California Division of Oil, Gas and Geothermal Resources (DOGGR) and the U. S. Environmental Protection Agency (EPA) (Attachment 1). This aquifer exemption was granted for the entire Tulare Formation based on it being a non-hydrocarbon producing zone being used for the disposal of wastewater. CRC also received concurrence from the SWRCB that protected groundwater is not present in Section 9, T32S/R24E (ftp://ftp.consrv.ca.gov/pub/oil/SWRCB%20Concurrence%20Letters%20and%20Groundwater%20Monitoring%20Exemption%20Documents%20Directory/Calif.%20Res.%20Corp.%20Buena%20Vista%20Field%20Section%209D/Letter%20of%20Concurrence%20Calif%20Res%20Corp%20Buena%20Vista%20field%20Section%209D.pdf).

Upper and Lower Confining Zones: The upper and lower confining zones of the proposed Lower Tulare injection interval are the Amnicola Claystone and the San Joaquin Formation, respectively (Attachment 5). The ability of the Amnicola Claystone and the San Joaquin Formation to vertically confine injectate to the proposed interval is based on their petrophysical properties, thickness, and lateral continuity, which will be discussed separately in the following sections.

[8] A Tulare aquifer exemption area Class II UIC operations has been requested by CRC for this area of the Elk Hills field (San Joaquin Energy Consultants, 2014).

[9] S refers to T30S/R24E.

Amnicola Claystone: The Amnicola Claystone is the confining zone between the proposed Lower Tulare injection interval and the overlying USDW. Because there do not appear to be any USDWs underlying the Lower Tulare, it is the more important of the two confining zones.

Permeabilities and porosities of the Amnicola Claystone were based on a conventional core analysis from the 1CH-27R well (Attachment 20). The vertical permeability, which is a direct measure of the ability of the Amnicola Claystone to impede upward fluid flow, was less than 0.1 md. An average permeability value of less than 100 md was considered to be low by Werner and Lehr (1981). The porosity in the Amnicola Claystone was not analyzed in that sample.

At the locations of the proposed EHP wells, the Amnicola Claystone occurs at estimated depths from 588 to 835 feet and ranges in thickness from 57 to an estimated 61 feet (Table 5; Attachment 21). An unconformity at the top of the Amnicola Claystone is believed to cause some minor variations in thickness. It is an easily recognized well log marker horizon, and correlations throughout all of the cross-sections indicate that it has excellent lateral continuity in the 1B/2B area (Attachment 7) as well as throughout much of the Elk Hills field. No faults have been identified in the area of review based on subsurface mapping.

Table 5: Summary of Amnicola Claystone Geologic Data

Well	Amnicola Claystone Depth (feet)	Amnicola Claystone Thickness (feet)
15-1B (conversion)	668 (from log)	57 (from log)
26-EHP-WD-1B	588 (projected)	61 (projected)
77-EHP-WD-2B	737 (projected)	58 (projected)
47-EHP-WD-2B	835 (projected)	58 (projected)
Average:	**707**	**58.5**

In the northern area of 1B/2B, the Amnicola Claystone is present, but there appears to be no groundwater in the Upper Tulare (Attachment 7). Where Upper Tulare groundwater does occur, vertical confinement of the proposed injection zone from any overlying groundwater is demonstrated by the low vertical permeability, good thickness, and excellent lateral continuity of the Amnicola Claystone in the 1B/2B area.

San Joaquin Formation: The San Joaquin Formation, which underlies the Lower Tulare, consists primarily of shale and silt and contains characteristic marine fossils and shells. There are no known USDWs within or underlying the San Joaquin Formation, as discussed on page 12 of this section (Attachment 18). Permeabilities and porosities of the San Joaquin Formation were based on conventional core data from the 64-34R well, which are summarized in Table 6. Permeabilities

in silts and silty sands averaged 1.6 and 33.1 md, respectively. As discussed in the preceding section, an average permeability value of less than 100 md is low (Werner and Lehr, 1981) and demonstrates that the San Joaquin Formation is an effective, lower vertical confining zone. Porosities in the San Joaquin Formation ranged from averaged 37% to 38%.

Table 6: Permeability and Porosity in the San Joaquin Formation from the 64-34R Well

Lithology	Avg. Permeability (md)	Avg. Porosity (%)
Silts	1.6	38.5
Silty Sands	33.1	38.1
Sands	843.3	37.4

The structure of the top of the San Joaquin Formation, which is an unconformity, is approximated by the structure on the base of the Lower Tulare A (Attachment 9). At the locations of the proposed EHP wells, the San Joaquin Formation occurs at depths from 1,210 to an estimated 1,310 feet and ranges in estimated thickness from 1,141 to 1,215 feet (Table 7; Attachment 22). It has excellent lateral continuity in the 1B/2B area (Attachment 7) as well as throughout much of the Elk Hills field. No faults have been identified in the area of review based on subsurface mapping.

Table 7: Summary of San Joaquin Formation Geologic Data

Well	Base Lower Tulare Depth (feet)	San Joaquin Formation Thickness (feet)
15-1B (conversion)	1,210 (from log)	1,201 (from log)
26-EHP-WD-1B	1,220 (projected)	1,141 (projected)
77-EHP-WD-2B	1,270 (projected)	1,215 (projected)
47-EHP-WD-2B	1,310 (projected)	1,189 (projected)
Average:	**1252.5**	**1186.5**

Although there are no known USDWs within or below the San Joaquin Formation, its low permeability as well as its excellent thickness and lateral continuity indicate that the formation would act as an effective lower confining zone.

Oil or mineral production history:

There is no known history oil or gas production in the Lower Tulare within the 1,500-foot area of review.

Are there any public or private drinking water wells within and nearby the proposed exempted area for which the proposed exempted portion of the aquifer might be a source of drinking water? Y/N If yes, list all those wells: No.

All water well drillers in California are required to submit Well Completion Reports to the DWR, which shares these data with the KCWA. Water well records within the area of review were searched using data from the KCWA, the DWR Water Data Library, the DWR California Statewide Groundwater Elevation Monitoring (CASGEM) Program, the Kern County Environmental Health Services Department (KCEHSD), the U. S. Geological Survey (USGS) National Water Information System, and USGS Professional Paper 912. There are no known water wells within the 1,500-foot area of review in any of these databases or to a distance of at least three miles from the proposed EHP well locations (Attachment 3). However, the KCEHSD only keeps records of well destructions for about five years before they are discarded. Also, the agency did not begin keeping records of water wells until the mid-1980s. Attachment 3 shows the nearest wells to the proposed EHP well locations, all of which are located a minimum of three miles away.

The current status[10] of all water wells located within at least three miles of the proposed EHP well locations was verified by site reconnaissance conducted by Quad-Knopf for this application and by an earlier Quad Knopf water well survey for the OEHI Tulare aquifer exemption for the Elk Hills field (San Joaquin Energy Consultants, 2014; Attachment 3). Based on searches of water well databases, well records review, and site reconnaissance, there are no known drinking water wells located within the 1,500-foot area of review or to a distance of at least three miles from the proposed EHP well locations.

The West Kern Water District (WKWD), which is the primary supplier of municipal and industrial water in this area, declared that the Tulare aquifer does not currently serve as a source of drinking water and would not reasonably be expected to supply a public water system in the OEHI project area (Attachment 2). CRC, the parent company of EHP, owns all of the surface rights in sections 1B, 2 B, 3 B, 10 B, 11 B, and 12 B. Neither EHP nor CRC has any active water source wells in the Elk Hills field because all of the process water for the EHPP and water needed for oil and gas operations in the Elk Hills field are purchased from the WKWD.

- *Include*: Pertinent map(s) visually showing the areal extent of exemption boundary, depth and thickness of the aquifer proposed for exemption, all known subsurface structures such as faults affecting the aquifer, and each of the inventoried water well locations by well # or owner name.

  Please see Attachment 8 through Attachment 14. As discussed on page 16 of this application, no known domestic, irrigation, or other water wells are located within the

[10] Active, idle, or destroyed/abandoned.

1,500-foot area of review or to a distance of at least three miles from the proposed EHP well locations (Attachment 3).

- *Include:* Tables of all inventoried water wells showing: Well Name/#, Owner, (Private/Public), Contact information, Purpose of well (Domestic, Irrigation, Livestock, etc.), depth of source water, name of aquifer, well completion data, age of well (if known), and the primary source of well data (Applicant/State/Tribe/EPA).

  As discussed on page 16 of this application, no known domestic, irrigation, or otherwater wells are located within the 1,500 -foot area of review or to a distance of at least three miles from the proposed EHP well locations (Attachment 3).

- *Include:* Map showing the areal extent of exemption boundary, all domestic water wells considered potentials down gradient of the exemption and hydraulically connected to the exemption. If wells are deemed horizontally and/or vertically isolated from the exemption, this should be foot noted on the Table as well. Use arrows to indicate the direction and speed of the GW in the aquifer proposed for exemption.

  As discussed on page 16 of this application, no known domestic, irrigation, or otherwater wells are located within the 1,500 -foot area of review or to a distance of at least three miles from the proposed EHP well locations (Attachment 3).

- Describe the evidence presented in the application and/or methodology used to conclude GW direction and speed when relevant.

  Groundwater Flow Direction: As discussed in the "Groundwater Flow Direction" section on page 12 of this application, s ite-specific Information on Lower Tulare groundwater elevations or flow direction was not available in the area of review and was not mapped regionally by the DWR (2006) or the KCWA (2008). The direction of groundwater flow within the Lower Tulare is assumed to be south -southwesterly based on the local topography and dip of the base of the Lower Tulare in the area of review (Attachment 1; Attachment 9).

  Groundwater Rate of Movement: No information was available to determine the rate of groundwater movement in the 1B/2B area.

- *Include:* Any source water assessment and/or protection areas and designated sole source aquifers located within the delineated area. None.

What is the appropriate area to examine for drinking water wells? Although guidance 34 says it should be a minimum of 1/4 mile, the determination of the appropriate area is on a case by case basis. Describe area and give a rationale.

The appropriate area to examine for drinking water wells was based on the injectate front and pressure front calculations for the permitted rate using one well, as discussed under "Regulatory Criteria" on pages 6 through 10 of this application. A 1,500-foot area of review was supported by these calculations. However, the water well survey was expanded to a distance of at least three miles from the proposed EHPP well locations and determined that there are no known drinking water wells within this area.

Are there any public or private drinking water wells or springs capturing (or that will be capturing) or producing drinking water from the aquifer or portion thereof within the proposed exemption area? Y/N No

- Evaluate the capture zone of the well(s) in the area near the proposed project (i.e., the volume of the aquifer(s) or portions(s) thereof from within which groundwater is expected to be captured by that well.

  As discussed on page 16 of this this application, no known domestic, irrigation, or other water wells are located within the 1,500-foot area of review or to a distance of at least three miles from the proposed EHP well locations (Attachment 3). There are no intermittent drainage courses in the Elk Hills field which meet the requirements for navigable waterways under Section 404 of the Clean Water Act and no known natural springs or other continuous sources of natural recharge within the Elk Hills field. Precipitation in the Elk Hills area averages only about 5.8 inches annually, with an average annual pan evaporation rate of about 108 inches in the Buttonwillow area [11]. Consequently, almost no groundwater from precipitation is available to recharge groundwater.

  A feature noted as a "reservoir" is located about one mile east of the proposed EHP well locations in Section 6G (Attachment 1). This feature was field-checked by Quad Knopf, which found a berm but no water at this location (Attachment 3). Quad Knopf considered it unlikely that this feature would act as a reservoir.

[11] Information Sheet on the Regional Water Quality Control Board website for Clean Harbors Buttonwillow, LLC.

- A drinking water well's current source of water is the volume (or portion) of an aquifer which contains water that will be produced by a well in its lifetime. What parameters were considered to determine the lifetime of the well?

  As discussed on page 16 of this application, no known domestic, irrigation, or otherwater wells are located within the 1,500 -foot area of review or to a distance of at least three miles from the proposed EHP well locations (Attachment 3).

  (*) If the answer to this question is Yes, therefore the aquifer currently serves as a source of drinking water.

Is the TDS of the aquifer or portion thereof proposed for exemption more than 3,000 and less than 10,000 mg/l? Yes. The determination that the TDS of Lower Tulare groundwater is more than 3,000 and less than 10,000 mg/l is based on both laboratory analyses(Attachment 15; Table 2; Figure 1) and salinity calculations. Salinity calculations are supported by their g ood correlations with the laboratory analyses of groundwater from the 82-2B and the 48-9G (Attachment 23), as discussed in the following sections.

TDS Content of the Lower Tulare from Groundwater Analyses : Laboratory analyses from the 82-2B and the 48-9G demonstrate that TDS concentrations in the Lower Tulare range from 7,168 and 20,000 mg/l, as discussed in the section on the TDS content of the aqifer on pages 4 through 6 of this application and the "TDS" section on page 10 (Attachment 15; Table 2; Figure 1).

In the deeper interval s of the Lower Tulare where TDS concentrations exceed 10,000 mg/l, groundwater is not a protected USDW by definition. In the shallower intervals, TDS concentrations ranged from 7,168 to 7,453 mg/l. Tulare groundwater generally shows a trend of increasing with depth (Attachment 7a through Attachment 7e). This results from its proximity to the underlying marine San Joaquin Formation as well as other deeper, marine rocks that contain connate water having naturally high salinity.

TDS Content of Lower Tulare Groundwater from Salinity Calculations: Calculations of salinity in this application follow guidelines published by the EPA (Davis, 1988). The Humble equation was selected because its critical parameters, including deep resistivity and density porosity, are available for the calculations. Also known as the RP Method, the Humble equation is the most widely-used formula for unconsolidated sands (Davis, 1988) that are typical of the Tulare Formation. Discussion of the method used for salinity calculations is included in Attachment 23.

Direct samples of groundwater salinity are available only from a small group of wells at Elk Hills. In general, these wells are former Tulare water source wells. Groundwater quality was sampled in order to analyze compatibility of Tulare groundwater with Miocene Stevens zone waterfloods. Most of these wells do not have full geophysical log suites. However, more recent nearby

development wells or water disposal wells do have complete log suites. Therefore, it is possible to compare sampled groundwater salinity to calculated salinity. A limitation of this analysis is that the former Tulare water source wells were completed over a very long interval. As a result, multiple intervals of varying calculated salinities are present within the borehole and contribute to the groundwater sampled.

Well 48-9G has some of the best groundwater salinity information at Elk Hills. Two intervals in the Lower Tulare were tested: a shallower interval from 595 to 935 feet, and a deeper interval from 1,040 to 1,275 feet (Attachment 15; Table 2; Figure 1). Two groundwater samples from the shallower interval had salinities of 7,453 and 7,168 mg/l TDS. Three samples from the deeper interval, taken over a week-long period, changed from 12,647 to 9,926 ppm TDS. The change in salinity may be caused by increased flow from more permeable sands having lower salinity. Three nearby wells, located within 600 feet of 48-9G, were selected for calculations of salinity (Attachment 23). The three wells record a progressive increase in salinity, from shallow to deep, generally ranging from about 6,000 mg/l TDS at about a measured depth of 600 feet to greater than 13,000 mg/l TDS near the base of the Tulare. For both the shallower and deeper tested intervals, all sampled formation water salinity measurements fell within the range of calculated salinity values in stratigraphically equivalent intervals, and the principle that salinity increases with depth in the Tulare Formation is well-established in this example.

Elk Hills calculated salinity data compare closely to actual measured groundwater samples, or, more frequently, calculated values are less than actual groundwater sample values, with the error amount up to 30%. In no case do calculated values exceed actual groundwater samples values by more than 1%. The error may be caused by the large amount of open interval and that deeper, higher salinity formation water makes up a significant portion of the sample. In wells with more restricted sample intervals, such as 48-9G and 82-2B, errors ranged from 6 to 21%. This amount of error is consistent with that noted by Davis (1988). Based on this comparison, calculated salinity is equal to or less than values from actual tested groundwater samples.

Salinity in at least the lowermost 240 feet of the basal Tulare is greater than 10,000 mg/l TDS. This calculation of high salinity is confirmed by formation water tests in well 48-9G. Comparison of calculations using the RP method, or Humble equation, and formation water tests shows that calculated salinity is equal to or less than the actual groundwater analyses, but the underestimation error is no more than 21%.

The groundwater sample from the 82-2B contains 20,000 mg/l TDS (Attachment 15; Table 2; Figure 1). Calculated salinity for the same stratigraphic interval in adjacent well 13-1B-RD1 ranges 13,000 to 16,000 ppm in the cleanest intervals (Attachment 23; Attachment 24 at 1,060 feet). Deeper stratigraphic sands in the Lower Tulare in adjacent wells have even higher calculated salinities, ranging to a maximum of 24,000 mg/l. In well 351-2B, all sands located below the unsaturated interval (about 240 feet of measured thickness) contain calculated salinity greater than 12,000 ppm (Attachment 25). The groundwater sample obtained from well 82-2B,

plus the calculated salinity in well 351 -2 indicate that at least the lowest 240 feet of the Tulare Formation does not qualify as protected water.

Calculated salinities are included on all of the cross -sections in Attachment 7 and illustrate the general trend of increasing salinity with depth in the Lower Tulare. The approximate boundary between Lower Tulare intervals having TDS concentrations less or more than 10,000 mg/l are shown in blue-green and green shading, respectively, on the cross-sections (Attachment 7).

Is the aquifer proposed for the exemption or portion thereof not reasonably expected to supply a public water system? There is no reasonable expectation that Lower Tulare groundwater will supply a public water system, as discussed below.

- Identify and discuss the information on which the determination that the total dissolved solids content of the ground water in the proposed exemption is more than 3,000 and less than 10,000 mg/l and the aquifer is not reasonably expected to supply a public water system.

  Include information about the quantity and availability of water from the aquifer proposed for exemption. Also, the exemption request must analyze the potential for public water supply use of the aquifer. This may include: a description of current sources of public water supply in the area, a discussion of the adequacy of current water supply sources to supply future needs, population projections, economy, future technology, and a discussion of other available water supply sources within the area.

  Supply of a Public Water System: A public water system is defined as a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly se rves at least twenty -five individuals (http://water.epa.gov/infrastructure/drinkingwater/pws/pwsdef2.cfm).

  Lower Tulare groundwater is not reasonably expected to supply a public water system because its TDS and other constituents are unsuitable for use as drinking water. Near the base of the Lower Tulare, TDS concentrations based on laboratory analyses exceed 10,000 mg/l and disqualify it as a protected USDW in both the 82-2B and 48-9G wells (Attachment 15; Table 8). The non-protected Lower Tulare groundwater in the 82-2B well also has a concentration of selenium that exceeds the primary maximum contaminant level (MCL) for drinking water. Poor groundwater quality in the shallower parts of the Lower Tulare is demonstrated by laboratory analyses from the 48-9G, which indicate that:

  1) TDS, chloride, and sulfate concentrations greatly exceed recommended secondary drinking water MCLs;

2) Iron concentrations are more variable but also can be significantly higher than the secondary drinking water MCL; and

3) Boron and strontium concentrations exceed the EPA's lifetime health advisory (LHA) limits for protecting human health.

Table 8: Groundwater Constituents in the Lower Tulare near the Proposed EHP Wells

Well No. / Constituent	82-2B Conc. (mg/l)	48-9G Minimum Conc. (mg/l)	48-9G Maximum Conc. (mg/l)	MCLs and Regulatory Thresholds (mg/l)	Threshold Exceeded?	% of Threshold
Selenium[1]	0.720	--	--	0.05	Yes	1440%
TDS[2]	20,000	7,168	12,647	500	Yes	1,434% to 4,000%
Chloride[3]	10,000	2,584.9	6,049.5	250 (recommended)	Yes	1,034% to 4,000%
Sulfate[4]	320	1,800	2,016.0	250 (recommended)	Yes	128% to 1110%
Iron	--	0.12	37.0	0.3	Yes	40% to 12,333%
Boron[5]	5.7	6.0	9.4	<0.5 - >3.0	Yes	190% to 1,880%
Strontium[6]	17	--	--	4	Yes	425%

NOTES:

All concentrations and regulatory limits are in mg/l.

Primary MCLs are shown in red if exceeded.

Secondary MCLs are shown in orange if exceeded.

Other regulatory thresholds are shown in yellow if exceeded.

[1]Primary MCL for selenium: 0.050 mg/l

[2]Secondary MCLs for TDS: recommended = 500 mg/l; upper = 1,000 mg/l; short term = 1,500 mg/l

[3]Secondary MCLs for chloride: recommended = 250 mg/l; upper = 500 mg/l; short term = 600 mg/l. The chloride water quality guideline for sprinkler irrigation is <106 mg/l. Irrigation water for sensitive crops is recommended to be <142 mg/l.

[4]Secondary MCLs for sulfate: recommended = 250 mg/l; upper = 500 mg/l; short term = 600 mg/l.

[5]The EPA's lifetime health advisory (LHA) for boron is 6 mg/l, and its drinking water equivalent level (DWEL) for boron is 7 mg/l.

[6]The EPA's LHA level for strontium is 4 mg/l for a 70-kg adult consuming 2 liters water/day.

Quantity, Availability, Current Sources, and Adequacy of Groundwater: The proposed 1B/2B aquifer exemption area is located on the southwestern side of the San Joaquin Valley in a remote, unincorporated part of Kern County (Attachment 4). It lies entirely within the boundaries of the WKWD. The WKWD serves the cities of T aft and Maricopa as well as McKittrick, Ford City, and other Westside communities near the proposed aquifer exemption area. It sells water to a permanent population of about 18,600, with about 7,400 service connections, of which about 7,000 are for domest ic users. The area served by the WKWD covers about 300 square miles (Kern County Water Agency, 2011).

Total annual water use in the WKWD in 2010 was 24,729 acre -feet, or 216 gallons per capita per day, including significant quantities of water used by ind ustries in the district

(West Kern Water District, 2011). About 80 percent of the WKWD's water sales are to industry, and the remaining 20% are domestic water sales. It also supplies minor water for landscaping and recreational use.

The WKWD contracted with the KCWA in 1966 to deliver water from the State Water Project (SWP) via the California Aqueduct. Since 2002, the WKWD has had a SWP entitlement of a maximum 31,500 acre-feet per year, with an additional 10,000 acre-feet per year under the interruptible SWP contract when high-flow water is available from the Delta. The h igh-flow water typically is purchased by the WKWD for its groundwater banking program.

The WKWD has two turnouts along the California Aqueduct but only uses one to deliver untreated water to industrial customers CRC and La Paloma Generating Company, LLC (LPGC). A maximum of 6,500 acre-feet of water can be used by LPGC. However, because LPGC has historically used less than the maximum, the WKWD has been able to use the remainder for groundwater recharge or exchange with other entities. Except for the delivery of untreated water from the California Aqueduct to LPGC, surface water is not used directly by the WKWD as a domestic water supply source (West Kern Water District, 2011).

The majority of the WKWD's SWP water is received through an in -lieu groundwat er pumping/groundwater banking exchange with the Buena Vista Water Storage District (BVWSD). The BVWSD receives water from the Kern River, the SWP, and local groundwater wells. The exchange between the BVWSD and the WKWD involves the BVWSD taking WKWD SWP water rather than producing groundwater from its wells. The WKWD then can either pump or bank the equivalent amount of SWP water used by the BVWSD. In wet years, when the BVWSD can meet its water demands from the Kern River, it does not have to take SWP water from the WKWD. Instead, the SWP water is delivered to the WKWD groundwater recharge area and credited to its banking program. Because the WKWD has historically needed less water than the SWP water exchanged with the BVWSD, it has banked any surplus water. For the period from 1977 to 2010, this surplus averaged 17,418 acre-feet per year. At the end of the 2010 water year, there was a total surplus of 208,157 acre -feet, including 31,483 acre -feet owed to the WKWD from other agencies (WKWD, 2011).

The WKWD's domestic water needs also are supplied by the South Well Field near Tupman, which is located about two miles northeast of the Elk Hills field, and the new North Well Field, located about three miles east of the Elk Hills field The South Well Field and recharge ponds are located adjacent to the Kern Wa ter Bank recharge area . Well depths in the Tupman well field range from 650 to 850 feet. The total peak production capacity is 99 acre -feet per day, but the maximum usage is 61 acre -feet per da y (West Kern Water District, 2011).

Based on historical usage, the WKWD and the BVWSD entered into an agreement in 1965 that allows the WKWD to pump a maximum of 3,000 acrefeet annually from the Tupman well field. This water cannot be banked and is used preferentially in any given year. The WKWD is required to recharge the groundwater basin for amounts pumped in excess of 3,000 acre-feet annually. At the end of the 2010 water year, the WKWD had an estimated 176,674 acre-feet of banked water.

The WKWD also has undertaken a new recharge and recovery project, referred to as the North Well Field Project. Water production capacity is expected to increase from the current 55,000 acre -feet to 100,000 acre -feet. The WKWD's website provides the following discussion on the new well field (http://wkwd.org):

> "The latest development The WKWD's North Well Field Project involves the construction of a new well field located on the axis of the Kern River between Interstate 5 and the California Aqueduct, which encompasses roughly 1000 acres. It will allow the District more flexibility and reliability in the development of its water supplies. Historically, the District has been entirely dependent on a single well field location to meet its water demands. In recent years, groundwater levels have seen great declines due to increased pumping to make up for the reductions in our annual State Water Project water supplies, and this newly acquired North Well Field Location allows the District a ccess to an additional 100,000 acre -foot block of stored groundwater underneath the project location. In addition, the project provides additional wells that allow for redundancy and flexibility in our water production operations. The first phase of the pr oject involves the construction of water wells and pipelines and is scheduled to become operational by the end of 2011. A subsequent phase calls for additional pipelines that should further increase operational flexibility."

There is an additional operating agreement between the WKWD and theKern Water Bank Authority (KWBA) for pumping and recharge activities. An opportunity also exists for the WKWD to connect to three KWBA water wells, which were permitted for use by both the WKWD and the KWBA. This pote ntial water transfer would be as much as 12,905 acre -feet.

As discussed in its 2010 Urban Water Management Plan, the WKWD's water needs in the Tulare aquifer exemption area were believed to be adequately served by existing and future sources for the following reasons:

- Current demand is well below production capacity;
- Since the 1970s, the WKWD's water needs have been less than the SWP supplies delivered via the exchange with the BVWSD;

- The WKWD has banked an average of 17,418 acre-feet of surplus water annually from 1977 to 2010;
- The new North Well Field is expected to nearly double production capacity in the WKWD;
- The WKWD did not believe that desalination of brackish water or groundwater was practical and has no current plans to pursue this method of treatment.

During a meeting with WKWD and CRC staff in September 2014, SJEC asked whether updated information on the Urban Water Management Plan was available and was told that the *2010 Urban Water Management Plan* (West Kern Water District, 2011) was the most current document.

Based on summaries of current and future water urban water demand and estimated demand by municipal/industrial category, it is estimated that the demand between 2010 and 2030 will increase by about 5.5 % annually (Attachment 26). However, because of the recent drought, the WKWD has initiated a Water Shortage Level 2, or "Alert/Water Restriction", condition and instituted certain mandatory water conservation measures (http://wkwd.org/filelibrary/file_76.pdf). Consequently, the 5.5% demand is likely to be overestimated because it was made before water usage restrictions were implemented for the current drought conditions.

Population Projections and Economy: The proposed aquifer exemption area is located in a remote, sparsely populated, and relatively low income area of California. According to California Census data, population in the towns surrounding the1B/2B area is generally low. There were low to negative population growth rates as of July 1, 2014, and low estimated population growth rates from 2014 to 2019, as previously discussed on page 1 of this application and summarized in Attachment 4.

Average per capita income data and estimated income growth rates for nearby towns are summarized in Table 9. The average 2014 per capita income for this area ranges from $11,152 to $22,036 and ranks near the lower end of all California cities in the database. The estimated per capita income growthrate was slightly more than 2%as of July 1, 2014.

Both population and income growth rates are believed to be overstated because when oil prices began collapsing in June 2014, the negative impacts to the local economy, which is depends to a large extent on oil, probably were not foreseen at the time the forecast was made.

Table 9: Per Capita Income Summary[12]

Town	Distance from 1B/2B Area	2014 Per Capita Income	Rank Based on 1,523 California Cities	Estimated Per Capita Income Growth Rate
Valley Acres	5.0 miles	$20,247	1,028	2.39%
Dustin Acres	5.3 miles	$20,149	1,037	2.39%
Tupman	7.0 miles	$21,968	946	2.55%
Fellows	7.2 miles	$15,813	1,284	2.12%
Derby Acres	7.3 miles	$22,036	940	2.55%
Ford City	7.3 miles	$11,152	1,445	2.65%
Taft	8.2 miles	$19,136	1,093	2.51%
McKittrick	9.4 miles	$21,923	947	2.57%
Buttonwillow	9.7 miles	$11,286	1,434	2.76%

Potential for Public Water Supply Use of the Lower Tulare Groundwater: The Lower Tulare is not reasonably expected to supplya public water supply system for the following reasons:

1. A public water system is a system that provides water for human consumption. The deeper intervals of the Lower Tulare throughout the 1B/2B area exceed 10,000 mg/l TDS. By definition, these intervals do not qualify as a protected USDW and could not be used to supply a public water system.
2. In the shallower intervals of the Lower Tulare where TDS concentrations are less than 10,000 mg/l, groundwater can significantly exceed secondary drinking water standards and LHAs that are protective of human health. As such, Lower Tulare groundwater would be unfit to supply a public water system.
3. Current and future sources of drinking water in the 1B/2B area include SWP water via the California Aqueduct, groundwater pumping from well fields completed in shallow alluvial aquifers that are located off the north flank of Elk Hills , recharge from groundwater banking, and exchanges between water districts. All of these sources have water that is significantly higher in quality and is more readily available than Lower Tulare groundwater.
4. The quantity and availability of current and fu ture sources of drinking water ha ve been impacted by the recent drought conditions, but water conservation measures have been implemented by the WKWD and other water agencies/districts to reduce demand and conserve resources.

[12] All data as of July 1, 2014. Source: http://california.hometownlocator.com/

5. Population is low in the town s surrounding the 1B/2B area , and recent p opulation growth rates have been low to negative.
6. Recent per capita income in surrounding towns ranks in the lowerend of all California cities and towns.
7. Both the estimated population and income growth rates may be overst ated because the recent collapse in oil prices is likely to have adverse effects on the local, oil - dependent economy.
8. The WKWD, which is the primary supplier of municipal and industrial water in this area, declared that the Tulare aquifer does not currently serve as a source of drinking water and would not reasonably be expected to supply a public water system in the OEHI Elk Hills project area (Attachment 2).
9. CRC, the parent company of EHP, owns all of the surface rights in sections 1, 2, 3, 10, 11, and 12, T31S/R24E. At this time, it has no plans to use Lower Tulare groundwater because it purchases all of the industrial water used for the EHPP and petroleum operations from the WKWD.

Respectfully submitted,

Donna M. Thompson

California Licensed Professional Geologist No. 5347
California Certified Hydrogeologist No. 241

Please note that all geologic maps, cross -sections, discussion s of net sand and salinity calculations, and salinity calculation exhibits and some discussion of groundwater characterization in this document were prepared by under the supervision of Mr. Stephen A. Reid, California-licensed Professional Geologist No. 3876.

REFERENCES

Ayers, R. S. and D. W. Westcot, 1994. *Water Quality for Agriculture*, FAO Irrigation and Drainage Paper 29, Rev. 1.

Bechtel Petroleum Operations, Inc., 1998. *Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1: Summary of Data, January 1996 through February 1998*: December 1998.

Bechtel Petroleum Operations, Inc., 1997. *Ground Water Protection Management Program*: April 1994, revised October 1995: Revision 3.

Bechtel Petroleum Operations, Inc., 1994. *NPR-1 Ground Water Protection Management Program*: April 1994, revised February 1995.

Berryman, W. M., 1973. *Lithologic Characteristics of Pliocene Rocks Cored at Elk Hills, Kern County, California*: U. S. Geologic Survey Bulletin 1332-D.

Bertoldi, G. L., R. H. Johnston, and K. D. Evenson, 1991. *Ground Water in the Central Valley, California – A Summary Report*, U. S. Geological Survey Professional Paper 1401-A.

California Department of Conservation, 2015. Selected production and injection data from the Division of Oil, Gas, and Geothermal Resources website: http://www/opi.consrv.ca.gov/opi/.

California Department of Conservation, 2008. *U. I. C. Exempt Aquifers for Class II Injection Wells (Kern, Tulare, and Inyo Counties)*, Division of Oil and Gas, and Geothermal Resources District 4.

California Department of Conservation, 1998. *California Oil Fields, Central California*: Division of Oil and Gas, and Geothermal Resources, Publication TR11, vol. 1, Sacramento.

California Department of Conservation, 1981. Application for Primacy in the Regulation of Class II Injection Wells under Section 1425 of the Safe Water Drinking Act. April 1981.

California Department of Conservation, 1973. *California Oil Fields, Central California*: Division of Oil and Gas, and Geothermal Resources, Publication TR11, vol. 1, Sacramento.

California Department of Water Resources, 2006. "San Joaquin Valley Groundwater Basin, Kern County Subbasin," in *Ground Water Subbasins in California*, Bulletin 118, updated: 1/20/06, website: http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/pdfs_desc/5-22.14.pdf.

California Department of Water Resources, 2014. Water Data Library: http://www.water.ca.gov/waterdatalibrary/.

California Gazeteer, 2015. Selected population and economic data on cities in Kern County from website: http://california.hometownlocator.com/.

California Regional Water Quality Control Board, Central Valley Region, 2004. *Water Quality Control Plan for the Tulare Lake Basin, Second Edition*, revised January 2004 (with Approved Amendments).

Croft, M. G., 1972, Subsurface geology of the Late Tertiary and Quaternary water-bearing deposits of the southern part of the San Joaquin Valley, California: Contributions to the hydrology of the United States, v. Geological survey water-supply paper 1999-H.

Davis, K.E., 1988, Survey of Methods to Determine Total Dissolved Solids Concentration: U.S. Environmental Agency Underground Injection Control Program, Washington, D.C.

Kennedy/Jenks, 2002. *Evaluation of Economic Feasibility of Treating McKittrick Area Groundwater for Use as Drinking Water,* prepared for La Paloma Generating Company, LLC, unpublished (released with permission).

Kern County Water Agency, 1987. *Water Supply Report, 1986*.

Kern County Water Agency, 2008. *Water Supply Report, 2001*.

Kern County Water Agency, 2011. *Tulare Lake Basin Portion of Kern County Integrated Regional Water Management Plan Final Update*, prepared by Kennedy Jenks Consultants, November 2011.

Maher, J. C., R. D. Carter, and R. J. Lantz, 1975. *Petroleum Geology of the Naval Petroleum Reserve No. 1, Elk Hills, Kern County, California*, U. S. Geol. Survey Prof. Paper 912.

McPherson J. G., Miller D. D., 1990, Depositional Settings and Reservoir Characteristics of the Plio-Pleistocene Tulare Formation, South Belridge Field, San Joaquin Valley California, in: Kuespert, J. G. and Reid, S. A. (ed.), Structure, Stratigraphy, and Hydrocarbon Occurrences of the San Joaquin Basin, California: SEPM Paper #64 and AAPG Paper #GB65.

MHA Petroleum Consultants, 2012. "Elk Hills Power EPA UIC Application for Class I Non-Hazardous Injection Wells", prepared for Elk Hills Power, LLC, April 30, 2012 update.

Milliken, M., 1992. *Geology and Geohydrogeology of the Tulare Formation, 7G/18G Produced Water Disposal Area, South Flank NPR-1*: U. S. Department of Energy Technical Report.

Miller, D. D., 1999, Sequence Stratigraphy and Controls on Deposition of the Upper Cenozoic Tulare Formation, San Joaquin Valley, California, Stanford University PhD Dissertation.

Newman, G. H., 1973. "Pore-Volume Compressibility of Consolidated, Friable, and Unconsolidated Reservoir Rocks under Hydrostatic Loading": Journal of Petroleum Technology, February 1973.

Phillips, M. V., 1992. *Summary of Tulare Formation Groundwater Conditions along the South Flank of the Naval Petroleum Reserve No. 1, Elk Hills, Kern County, California*: U. S. Department of Energy.

Phillips, M. V., 1994. Unpublished Report - detailing oasis sites at NPR-1.

Planert, M. and J. S. Williams, *Ground Water Atlas of the United States, Segment 1 California Nevada, Central Valley Aquifer System*: Hydrologic Investigations Atlas 730-B, http://ca.water.usgs.gov/groundwater/gwatlas/valley/index.html

San Joaquin Energy Consultants, 2014. "Occidental of Elk Hills, Inc. Tulare Aquifer Exemption Document, Elk Hills Field", prepared for Occidental of Elk Hills, Inc.

University of California Cooperative Extension, 2007. *Kern Soil and Water:* "Permanent Crop Salt Tolerance," May 2007.

Werner, D. L., and J. H. Lehr, 1992. S*ubsurface Wastewater Injection: The Technology for Injecting Wastewater into Deep Wells for Disposal*, Premier Press, Berkeley, California.

West Kern Water District, 2011. *2010 Urban Water Management Plan*, prepared by Kennedy/Jenks Consultants, June 2011.

West Kern Water District, 1997. *Groundwater Management Plan*, February 1997.

LIST OF ATTACHMENTS

Attachment 18: Groundwater Analyses in the San Joaquin Formation

Attachment 19: State Water Resources Control Bo ard Concurrence with Determination of Absence of Protected Water in Section 36, T30S/R23E

Attachment 20: Porosities and Permeabilities of Clays and Silts in the Amnicola Claystone and Lower Tulare

Attachment 21: Isochore Map of the Gross Thickness of the Amnicola Claystone

Attachment 22: Isochore Map of the Gross Thickness of the San Joaquin Formation

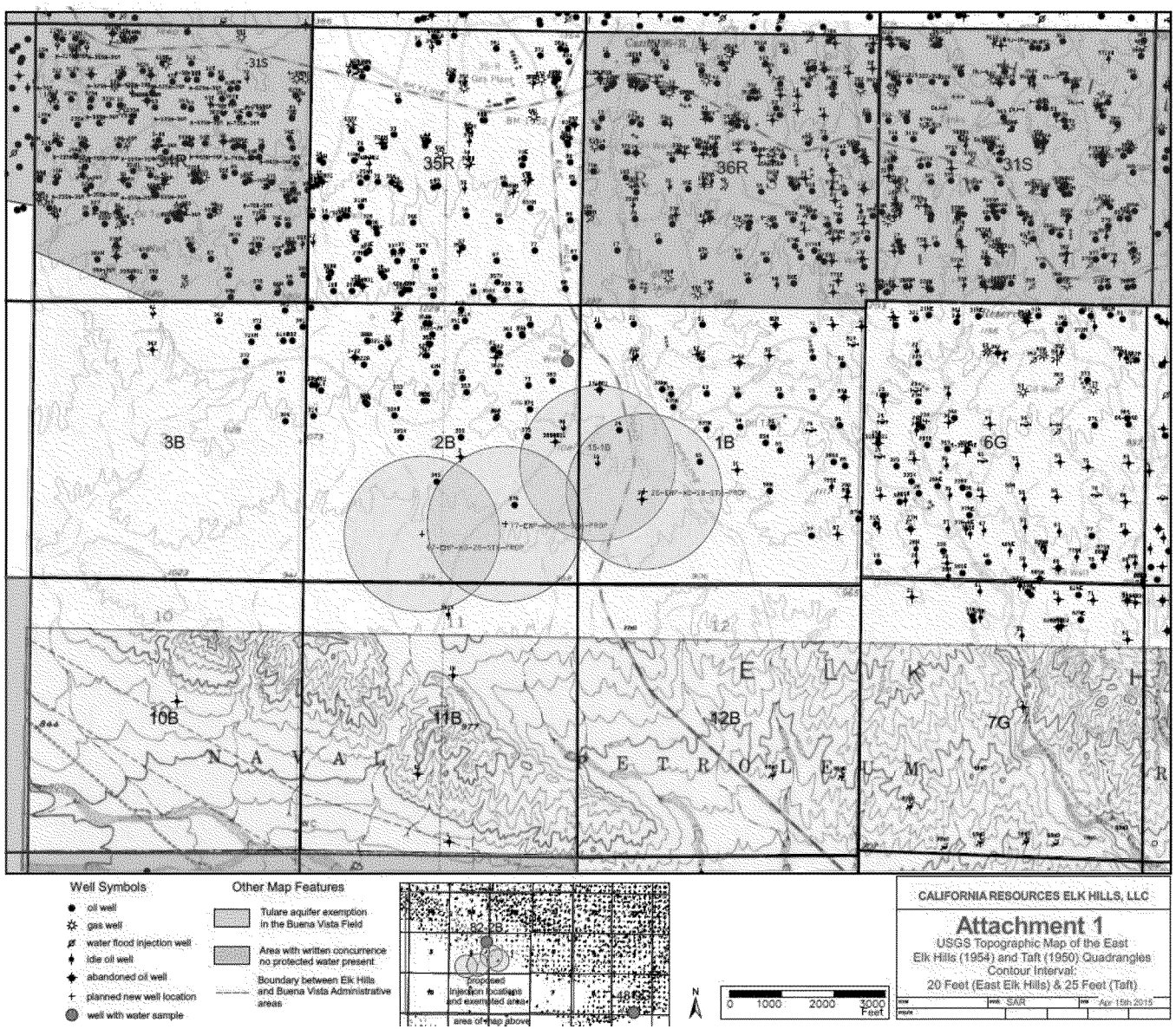
Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities

Attachment 24: Salinity Calculations in the 13-1B-RD1

Attachment 25: Salinity Calculations in the 351-2B

Attachment 26: Summary of Current and Future Water Demand for the West Kern Water District

Attachment 1: Topographic and Well Location Map of Proposed Elk Hills Power Aquifer Exemption Area and Area of Review



September 19, 2014

Mr. Bill Penderel
Associate Oil & Gas Engineer
Division of Oil, Gas, and Geothermal Resources
UIC Program
Via Email

RE: OCCIDENTAL ELK HILL, INC. TULARE AQUIFER EXEMPTION DOCUMENT ELK HILLS FIELD

Dear Mr. Penderel,

On May 15, 2014 San Joaquin Energy Consultants (SJEC) on behalf of Occidental of Elk Hills, Inc., (OEHI) contacted West Kern Water District (WKWD), stating they were in the process of preparing an application in the Elk Hills oilfield for an aquifer exemption for the Tulare Formation in portions of the Elk Hills project to allow Class II UIC Injection Operations, within the WKWD service area,.

SJEC requested WKWD provide the Division of Oil, Gas and Geothermal Resources a letter stating the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system within the project area as shown in the application map Exhibit 1-1 (and attached).

WKWD Staff and the District's consulting hydrogeologist have reviewed water quality data and various reports provided by SJEC within the project area and concluded the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system in the project area shown on the application map.

On September 15, 2014 the West Kern Water District – Board of Directors authorize Staff to issue a letter to the Division of Oil, Gas and Geothermal Resources stating the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system in the project area as shown on the application map Exhibit 1-1.

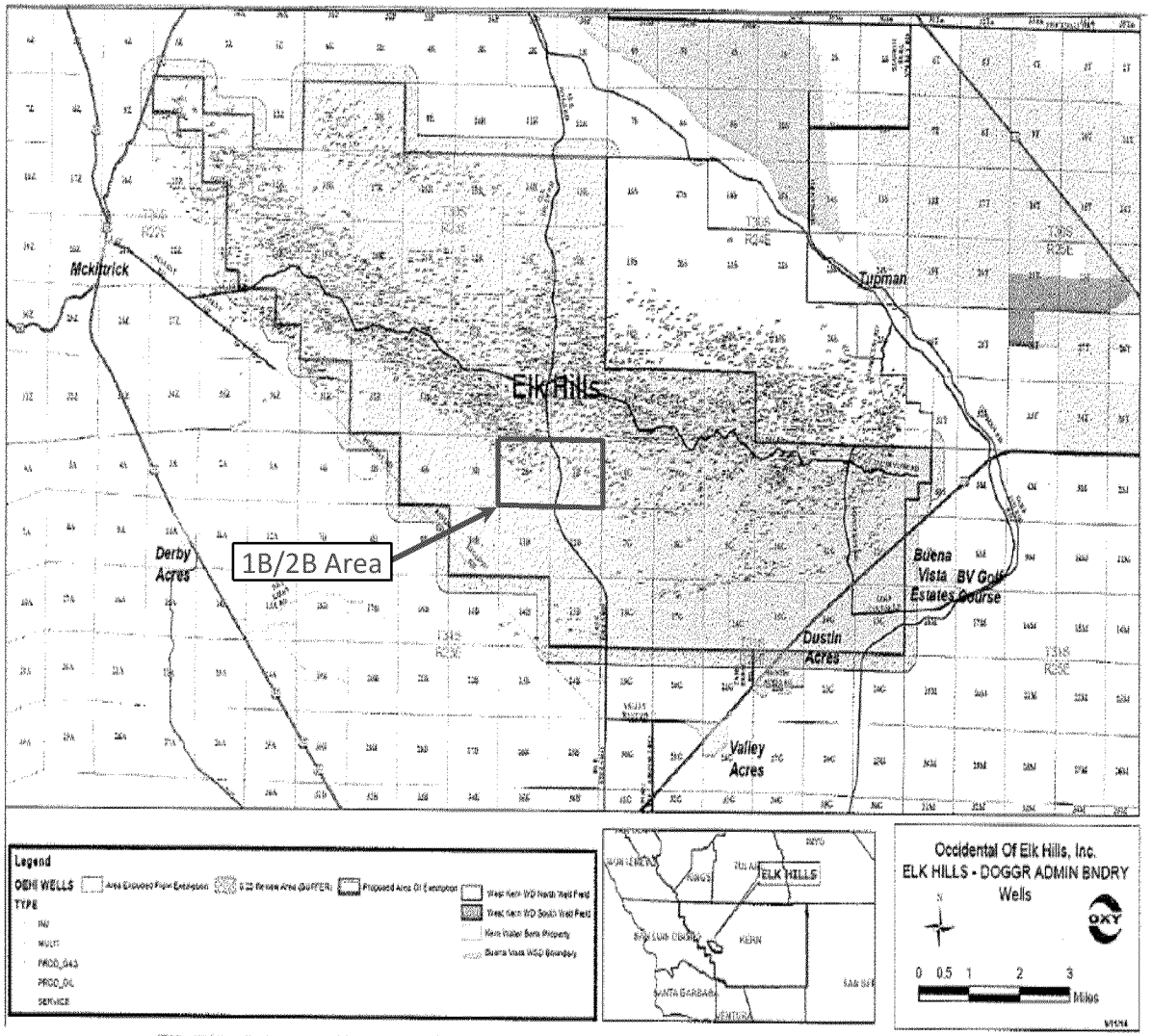
Should you require further correspondence regarding this subject please contact JD Bramlet of my Staff at (661) 763-3151.

Sincerely,

Harry O. Starkey
General Manager

West Kern Water District · 800 Kern St., P. O. Box 1105 · Taft, California 93268-1105 · 661 763-3151 · FAX 661 765-4271

Attachment 2: Declaration from the West Kern Water District, Page 2.



Elk Hills Tulare aquifer exemption area showing locations and types of wells within the area of review

Attachment 3: Survey of Water Wells and Springs within the Area of Review

The nearest KCWA wells are shown in the following table. No known water wells are located within 3 miles of the proposed EHP well locations.

SUMMARY OF WATER WELL SURVEY IN THE AREA OF REVIEW ELK HILLS POWER TULARE AQUIFER EXEMPTION APPLICATION Kern County Water Agency Well Files As of January 21, 2015								Domestic well Irrigation or Agricultural Industrial Well Other Types of Wells						NOTES: The nearest wells to the proposed EHP wells in the surrounding townships/ranges are shown. Wells shown in bold are within 3 miles of the proposed EHP wells, except for abandoned wells.
Sec.	T	R	Record #	Name	Owner	Address	Type	Date	TD	Depth to Water	Standing Water	Perfs	Rate	Comments
23	30	23	--	30S/23E-23K	So. Cal. Gas Co.	Rt. 1, Box 220, Taft	Ind.	10/75	--	--	--	--	--	No perfs noted. Probably a cathodic protection well. Location >3 miles from the proposed EHP wells.
19	**30**	**24**	**283566**	**30S/24E-19F**	**Cesar A. Vasquez**	**3734 Imperial Highway, Lynwood, CA**	**Dom.**	**9/13/1988**	**305'**	**128'**	**30'**	**200'-305'**	**15 gpm**	**APN 180-050-39-00-2: No information on KC Assessor parcel search. "Fractured granite" and black and/or white fractured granite noted in description. Location is about 3 miles northeast of the nearest proposed EHP well location. Quad Knopf conducted field reconnaissance and found no evidence of this well (Attachment 3, Quad Knopf letter dated 6/18/14).**
32	**30**	**24**	**44432**	**30S/24E-32**	**Opal Culp**	**Rt. 1, Buttonwillow**	**Dom.**	**1/17/1957**	**346'**	**32.5'**	**32.5'**	**310'-343'**	**--**	**100' S & 2400' W to section lines from well. Location is about 2 miles northeast of the nearest proposed EHP well. Site reconnaisance conducted by Quad Knopf and found no evidence of this within 500 feet of the well location (Attachment 3, Quad Knopf letter dated 6/18/14).**
23	31	22	300675	31S/22E-23B	Unocal R &M Div.	276 Tank Farm Rd., SLO	Ind.	8/3/1990	300'	--	--	215'-295'	--	Could be cathodic protection well. 1.2 miles W of Hwy. 33 & Shale Rd. Located about 6 miles from the nearest proposed EHP well location.
25	31	23	169007	31S/23E-25H	Kern County Public Works	2700 M, Bakersfield	Other	11/3/1988	440'	Dry	Dry	400'-420'	--	Monitoring well located in Taft Sanitary Landfill, about 3.5 miles south of the nearest proposed EHP well location. Good lithologic descriptions in "Log of Exploratory Boring".
25	31	23	373747	31S/23E-25	Kern County Waste Mgt.	2700 M, Bakersfield	Mon.	--	522'	--	--	--	--	Monitoring well located in Taft Sanitary Landfill, about 3.5 miles south of the nearest proposed EHP well location. TAI-08. "See Boring Log for details" but no log in well records.
25	31	23	373746	31S/23E-25	Kern County Waste Mgt.	2700 M, Bakersfield	Mon.	--	--	--	--	--	--	Monitoring well located in Taft Sanitary Landfill, about 3.5 miles south of the nearest proposed EHP well location. TAI-09. "See Boring Log for details" but no log in well records.
25	31	23	--	31S/23E-25C	Pacific Oil	--	Oil	12/4/1923	3015'	--	--	--	--	773' S & 2421' E of NW corner of section.
25	31	23	--	31S/23E-25B	Pacific Oil	--	Oil	6/5/1925	3100'	--	--	--	--	872' S & 1981' W of NE corner of section 25. Lithology available.
5	**31**	**24**	**--**	**31S/24E-5A4**	**Western Water Co.**	**--**	**--**	**9/23/1920**	**312'**	**11'**	**--**	**--**	**--**	**Lithologic descriptions available. Log of Well #11. Location is about 2 miles east of the nearest proposed EHP well. Quad Knopf conducted site reconnaisance throughout all of Section 5 and found no evidence of this well or any other water well listed below (Attachment 3, Quad Knopf letter dated 4/23/15).**
5	31	24	--	31S/24E-5A6	Western Water Co.	"Well No. 17"	Test	4/8/1905	52'	--	--	33'-52'	--	Abandoned.
5	31	24	--	31S/24E-5A7	Western Water Co.	"Well No. 18"	Ind.	4/8/1905	52'	--	--	33'-52'	--	Abandoned.
5	31	24	--	31S/24E-5A2	Western Water Co.	Water Well #6	"Abd"	1/1/1911	572'	--	--	--	2025 GPM	Plugged & abandoned. Cannot read location.
5	31	24	--	31S/24E-5A1	Western Water Co.	Water Well #5	"Abd."	9/22/1911	354'	--	--	--	--	750'S & 770'W of NE corner of section 5. Lithology available. Abandoned.
5	31	24	--	31E/24E-5A8	Western Water Co.	"Well No. 19"	Ind.	6/18/1924	50'	--	--	33'-50'	--	Abandoned.
5	31	24	--	31S/24E-5A5	Western Water Co.	"Well No. 16"	Ind.	12/12/1925	53'	--	--	3'-20'	--	Abandoned.
5	31	24	--	31S/24E-5A3	Western Water Co.	Water Well #7	"Abd"	~1911	317'	--	--	--	--	615'S & 900'W of NE corner of section 5. Abandoned. Note in file: "ABD water no good".
?	31	24	90385	31S/24E-?	C.A. Sanders	Rt. 3, Box 1074, Bakersfield	Irrig.	3/20/1974	460'	--	--	264'-444'	--	"Unconfined" noted on well record. 3 mi SW of Hwy 119 & Dustin Acres Rd., Dustin Acres. Checked well location: Located >3 miles from proposed EHP well locations.

Attachment 3: Survey of Water Wells and Springs within the Area of Review

The nearest KCEHSD wells are shown in the following table. No known water wells are located within about 6 miles of the nearest proposed EHP well location.

SUMMARY OF WATER WELL SURVEY IN THE AREA OF REVIEW								Domestic Well:						
ELK HILLS PROPOSED TULARE AQUIFER EXEMPTION APPLICATION								Agricultural Well:						
								Other Well:						
Kern County Environmental Health Department														
As of January 26, 2015										Depth to	Standing			
Sec.	T	R	Record #	Name	Owner	Address	Type	Date	TD	Water	Water	Perfs	Rate	Comments
23	30	24	EH-149-91 373834	30S/24E-23B	Buena Vista Water Storage District	P. O. Box 756, Buttonwillow	Ag.	9/13/1991	460'	--	--	180'-440'	--	Well No. 1. NW/4 NE/4. Survey map of 4 well locations in file: 1 well site with 4 locations. Permit Nos. EH-150-91, EH 149-91, and 148-91 referenced in well record but not found in records search. Located >6 miles from the nearest proposed EHP well.
25	31	23	EH-259-90	31S23E-25B	Kern County Public Works	2700 M St., #500, Bakersfield	Mon.	9/25/1990	462'	420'	420.51'	-400' to -440'	--	Monitoring well located in exempt Buena Vista field in Taft Sanitary Landfill. Tulare at surface. Good lithology descriptions.
25	31	23	EH-258-90	31S23E-25G	Kern County Public Works	2700 M St., #500, Bakersfield	Mon.	7/19/1990	502'	472'	462'	-400' to -440'	--	Well TA01-03. Monitoring well located in exempt Buena Vista field in Taft Sanitary Landfill. Tulare at surface. Good lithology descriptions.
25	31	23	WP12280	31S23E-25	Kern County Waste Mgt. Dept.	2700 M St., #500, Bakersfield	Mon.	±2/26/2010	400' Max.	--	--	-360' to -400'	--	Monitoring well located in exempt Buena Vista field in Taft Sanitary Landfill. From 119 westbound, ~14 mi W of I-5, right on Elk Hills Rd., ~1 mi to landfill on left.

The nearest CASGEM wells are shown in the following table. No known water wells are located within about 7 miles of the nearest proposed EHP well location.

CASGEM WELL SEARCH: 12/03/14

State Well Number	CASGEM Well Number	Local Well Designation	Monitoring Entity (ME)	Groundwater Basin/Subbasin Name	Groundwater Basin/ Subbasin Number	Type of Well	Status of Well	Well Usage	Total Well Depth	Measurement Count	Earliest Elevation Measurement Date	Most Recent Elevation Measurement Date	Minimum Groundwater Elevation Measured	Minimum Groundwater Elevation Measurement Date	Maximum Groundwater Elevation Measured	Maximum Groundwater Elevation Measurement Date	Latitude (NAD 83)	Longitude (NAD 83)
30S24E14H001M	353192N1193592W001	ElkP@	Buena Vista Water Storage District	Kern County	5-22.14	Voluntary	Active	Unknown	Confidential	119	2/3/1961 12:00 AM	10/24/2011 12:00 AM	0.000	10/2/1961 12:00 AM	250.840	10/1/1998 12:00 AM	35.3192	119.3592
30S24E14Q001M	353130N1193688W001	Anton	Buena Vista Water Storage District	Kern County	5-22.14	Voluntary	Active	Unknown	Confidential	30	4/14/1987 12:00 AM	9/23/2002 12:00 AM	0.000	10/1/1988 12:00 AM	257.840	1/2/1999 12:00 AM	35.313	119.3688

Attachment 3: Survey of Water Wells and Springs within the Area of Review

The nearest USGS National Water Information System wells are shown in the following table. No known water wells are located within 5 miles of the nearest proposed EHP well location.

USGS NWIS DATA						
As of December 10, 2014						
Site Name	Site Number	Site Category	Site Agency	Site Longitude	Site Latitude	Comment
T30S/R23E						
030S023E01C001M	352113119274001	GW	USGS	-119.46206190	35.35357340	Located ~6 miles from nearest proposed EHP well.
030S023E01C002M	352110119274001	GW	USGS	-119.46206190	35.35274009	Located ~6 miles from nearest proposed EHP well.
030S023E01L003M	352110119273501	GW	USGS	-119.46067290	35.35274008	Located ~6 miles from nearest proposed EHP well.
T30S/R24E						
030S024E22H001M	351823119224301	GW	USGS	-119.37955900	35.30635175	Located ~7 miles from nearest proposed EHP well.
T31S/R22E: No wells						
T31S/R23E: No wells						
T31S/R24E						
031S024E14M001M	351400119222601	GW	USGS	-119.37483700	35.23329776	Located ~5 miles from nearest proposed EHP well.
031S024E22B001M	351331119230801	GW	USGS	-119.38650430	35.22524246	Located ~5 miles from nearest proposed EHP well.
031S024E22H001M	351313119225101	GW	USGS	-119.38178190	35.22024257	Located ~5 miles from nearest proposed EHP well.
031S024E28B001M	351233119240401	GW	USGS	-119.40206060	35.20913180	Located ~5 miles from nearest proposed EHP well.
031S024E28L001M	351218119241401	GW	USGS	-119.40483850	35.20496528	Located ~5 miles from nearest proposed EHP well.
031S024E28Q001M	351154119241001	GW	USGS	-119.40372740	35.19829878	Located ~5 miles from nearest proposed EHP well.

Attachment 3: Survey of Water Wells and Springs within the Area of Review

Quad Knopf

June 18, 2014

Mr. Richard Garcia
Occidental Petroleum
28590 Highway 119
Tupman, CA 93276

Subject: Research for Occidental Petroleum on Potential Water Wells Located in the Following Sections: 17R, 13G, 14G, 18G,19S, 20S, 22S, 23S and 32S.

Dear Mr. Garcia:

Quad Knopf, Inc. is pleased to provide you with the results of our Water Well Research for the above referenced properties in support of Occidental Petroleum's DOGGR aquifer exemption application. We declare that we have performed the requested inquiry to the best of our professional knowledge and belief. Our services were provided in accordance with an email proposal dated May 16, 2014 with an email notice to proceed on May 20, 2014 from Brian Fowler.

As requested, Quad Knopf was to verify the presence or lack thereof, of water wells (irrigation or domestic) that fall within the bounds of the Elk Hills oil field, specifically for sections 17R, 13G, 14G, 18G, 19S, 20S, 22S, 23S and 32S.

In our records review and site reconnaissance visit for Occidental Petroleum Elk Hills research project, it was determined that a number of water wells (industrial, irrigation and domestic) were listed (current and historical) that fall within the bounds of the Elk Hills oil field (specifically in the sections requested or directly adjacent). Of these potential water wells two (2) were determined to be cathodic protection, one (1) an abandoned house with no evidence of a well, four (4) projected well sites had no evidence of a well within a 500+/- foot radius and one (1) well drilled in 1990 by Texaco Oil for industrial purposes that could not be located in Section 14G near the Dustin Acres residential development off of golf course road east of Highway 119. West Kern Water District provides all domestic water to the Dustin Acres residential area. See attached photoplates for additional detail. Therefore, based upon our research and reconnaissance it was determined that no domestic water wells are located within the Elk Hills oil field boundary (see attached map).

If you have any questions regarding this report, or need further information, please contact Kristie Achee or Heather Ellison at (661) 616-2600.

Quad Knopf, Inc

Kristie Achee
Survey Department Manager

5080 California Avenue, Suite 220, Bakersfield, CA 93309 • Tel (661) 616-2600 • Fax (661) 616-2970

Cover letter for field reconnaissance findings for the water well survey conducted by Quad Knopf for the OEHI Elk Hills Tulare aquifer exemption (San Joaquin Energy Consultants, 2014)

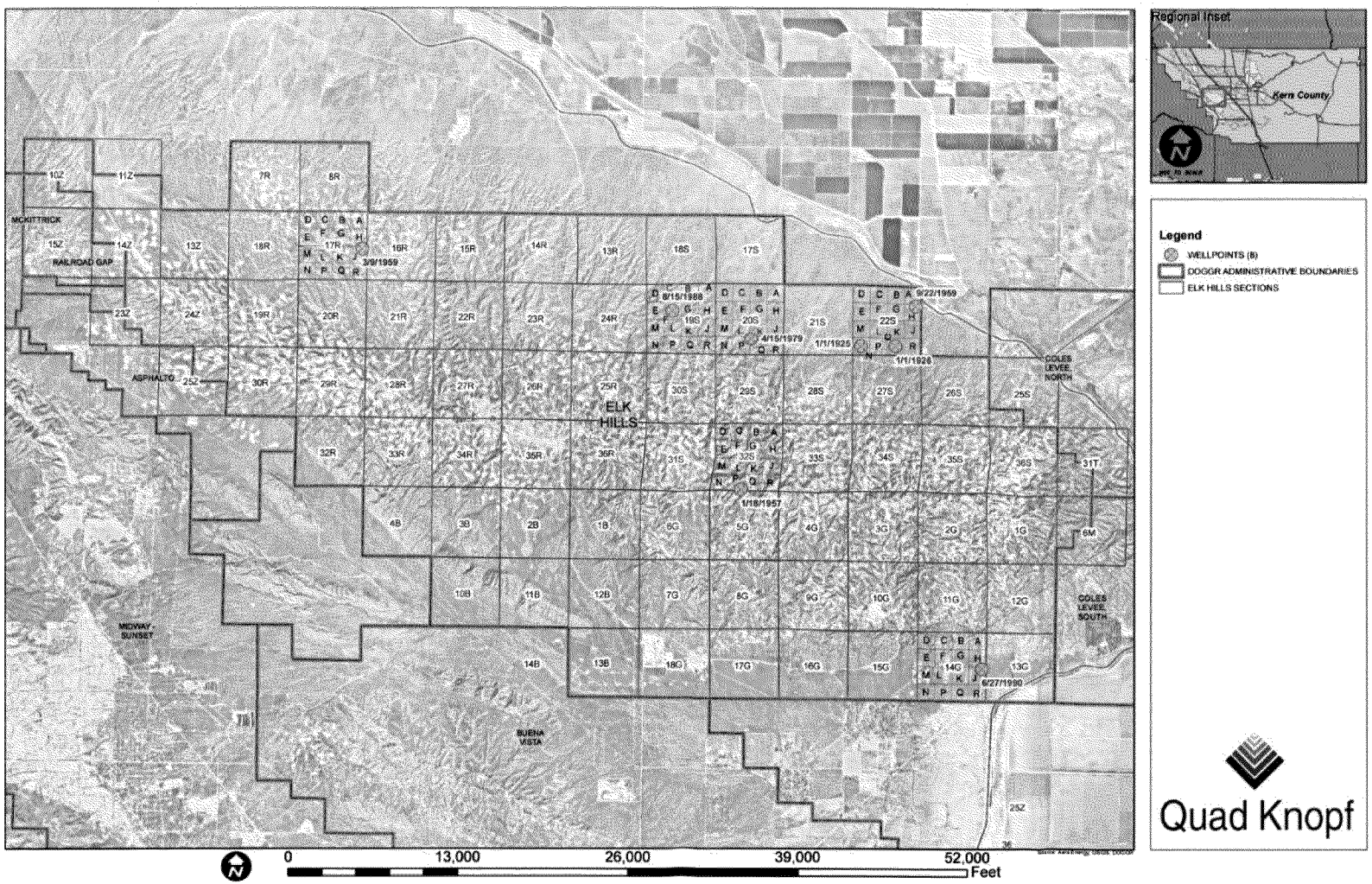
Attachment 3: Survey of Water Wells and Springs within the Area of Review

Site	Location - General	Defined Location	Date	Well No.	Depth	Oil or Water (Domestic/Irrigation)	Water Depth	Owner	Results of Site Reconnaissance
Sections Requested by Oxy: 17R, 13G, 14G, 18G,19S, 20S, 22S, 23S and 32S									
2	Section 17R (30S/23E)	65 Ft E to sec line, 2400 ft S to sec line from well	3/9/1959	17J	378	Irrigation	36	Orlando Torigiani	Anode well
3	Section 19S (30S/24E)	Tract 2139 APN 180-050-39-00-2	8/15/1988	19F 283566	305	Water (Domestic)	30	Cesar A. Vasquez	Nothing found within 500 ft radius
4	Section 20S (30S/24E)	NW corner of SW quarter of southeast quarter	4/15/1979	20Q 22135	780	Water (Industrial)	433	Naval Petroleum Reserve #1	Anode well/ not in service
7	Section 22S (30S/24E)	400 ft east to Section line from well, 1450 ft north	9/22/1959	22H 34225	348	water Irrigation	80	O.M Roberta	Nothing found within 500 ft radius
5	Section 22S (30S/24E)	Unknown*	1925	22N	1375	Unknown		Unable to read	Nothing found within 500 ft radius
6	Section 22S (30S/24E)	Unknown*	1926	22Q	3356	Uknown		Unable to read	No visible evidence of water well. House and other structures adjacent are abandoned.
8	Section 32S ((30S/24E)	100 ft south oto section line from well, 2400 ft west	1/18/1957	44432	346	domestic water	32.5	Opal Culp	Nothing found within 500 ft radius
9	Section 14G (31S/24E)	3/4 mi east of hwy 119 on golf course rd	6/27/1990	14H 278652	312	industrial water	N/A	Texaco USA	No evidence of well located within 500 ft radius. Location of well listed near the Dustin Acres residential development.

Note: Domestic water wells did not require any notification or permitting with the County prior to 1980.
* wells included on list due to extremely old dates and likelihood of the wells abandoned without record.

Summary of field reconnaissance findings for water well survey conducted by Quad Knopf for the OEHI Tulare aquifer exemption (San Joaquin Energy Consultants, 2014). Site 3 and Site 8 are located about 3.5 miles and 2.5 miles, respectively, of the nearest proposed EHP well location. No evidence of these wells was found within 500 feet radius of the locations

Attachment 3: Survey of Water Wells and Springs within the Area of Review



Field reconnaissance map for the water well survey conducted by Quad Knopf for the OEHI Elk Hills Tulare aquifer exemption (San Joaquin Energy Consultants, 2014). Site 3, labeled as 8/15/88 in Section 19S, and Site 8, labeled as 1/18/57 in Section 32S, are located about 3.5 and 2.5 miles, respectively, of the nearest proposed EHP well location. No evidence of these wells was found within 500 feet radius of their locations.

Attachment 3: Survey of Water Wells and Springs within the Area of Review

Quad Knopf

April 23, 2015

Mr. Rick Garcia
California Resources Elk Hills, LLC
28590 Highway 119
Tupman, CA 93276

Subject: Field Investigation for California Resources Elk Hills on Potential Water Wells Located in Section 5G (Section 5, T-31-S, R-24-E, M.D.M.).

Dear Mr. Garcia:

Quad Knopf, Inc. is pleased to provide you with the results of our Water Well field investigation for the above referenced property. We declare that we have performed the requested field investigation to the best of our professional knowledge and belief. Our services were provided in accordance with an email request dated April 9, 2015.

As requested, Quad Knopf was to verify the presence or lack thereof, of water wells that fall within the bounds of the Elk Hills oil field, specifically for section 5G. On April 10 and 11, 2015 we performed the field investigation for potential water wells in Section 5G.

Our crew scoured all of the property in section 5G. Of these potential water wells one (1) was determined to be cathodic protection and three (3) were determined to be out of service tilt meters. See attached photoplates for additional detail.

If you have any questions regarding this report, or need further information, please contact Kristie Achee or Joe Baiza at (661) 616-2600.

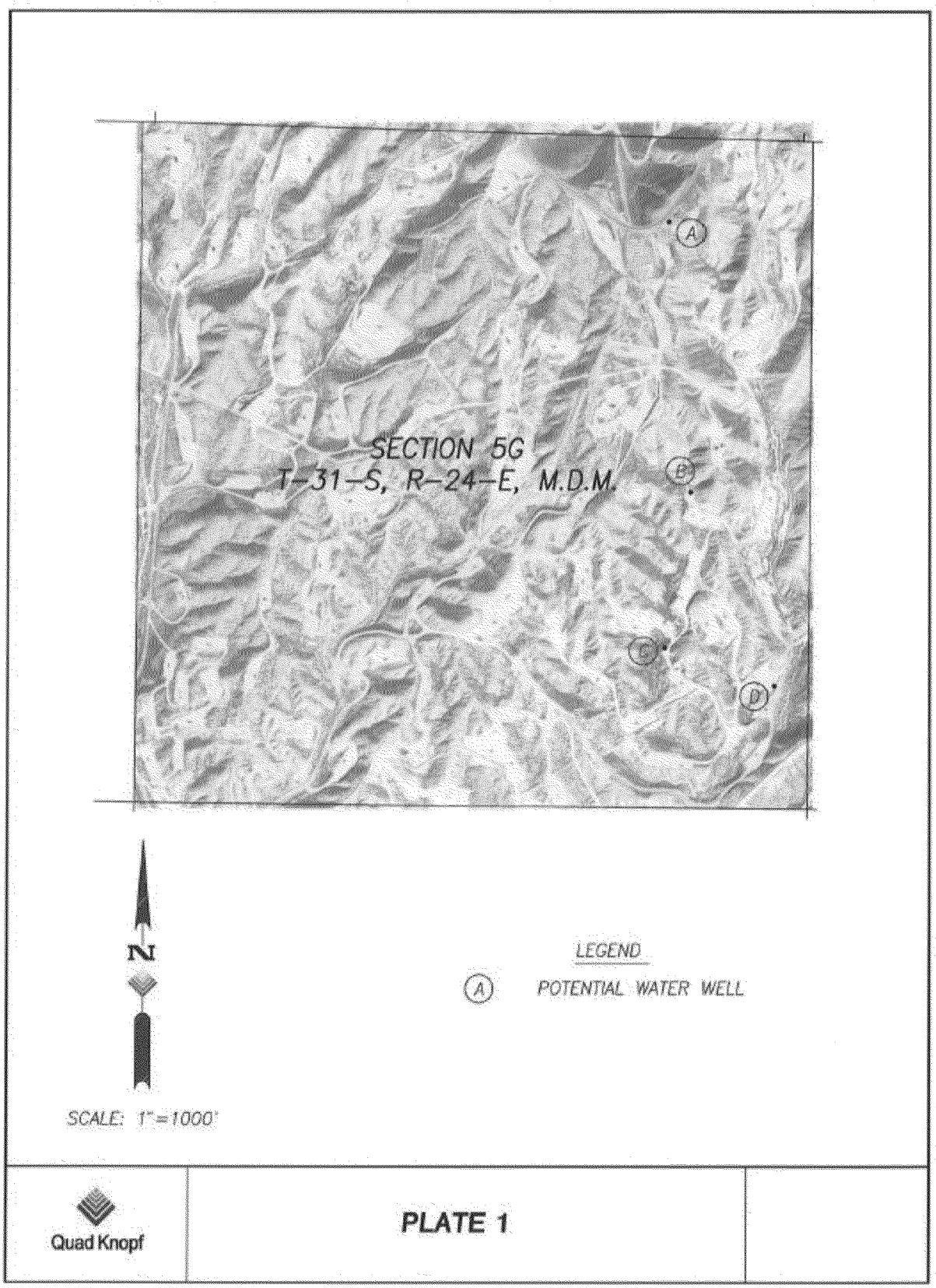
Quad Knopf, Inc

Kristie Achee, PLS
Survey Department Manager

5080 California Avenue, Suite 220, Bakersfield, CA 93309 • Tel (661) 616-2600 • Fax (661) 616-2970

Cover letter for field reconnaissance findings for the water well survey conducted by Quad Knopf for the Elk Hills Power aquifer exemption

Attachment 3: Survey of Water Wells and Springs within the Area of Review



Attachment to Quad Knopf Water Well Survey Letter

Well A

Well B

Quad Knopf	**PLATE 2**	

Attachment to Quad Knopf Water Well Survey Letter

Well C

Well D

Quad Knopf	PLATE 3	

Attachment to Quad Knopf Water Well Survey Letter

Attachment 3: Survey of Water Wells and Springs within the Area of Review

Quad Knopf

April 23, 2015

Mr. Rick Garcia
California Resources Elk Hills, LLC
28590 Highway 119
Tupman, CA 93276

Subject: Field Investigation for California Resources Elk Hills on Potential Reservoir Located in Section 6G (Section 6, T-31-S, R-24-E, M.D.M.).

Dear Mr. Garcia:

Quad Knopf, Inc. is pleased to provide you with the results of our Potential Reservoir field investigation for the above referenced property. We declare that we have performed the requested field investigation to the best of our professional knowledge and belief. Our services were provided in accordance with an email request dated April 9, 2015.

On April 10, 2015 Quad Knopf performed a field investigation for a potential reservoir at the location shown on the USGS Quad map "East Elk Hills" (photorevised 1973) in the vicinity of the North Quarter corner of Section 6G (see attached photoplate 1).

There was not, what we would consider, a reservoir at the location noted on the USGS Quad map. We found the overall topography of this portion of the section to be primarily hills with dry arroyos. Some of these dry arroyos, through construction of the access roads that are typically constructed in a working oilfield, have been essentially dammed. But, with the amount of rainfall in this area and the permeability of the soil, there is little potential of these areas acting as a reservoir. The natural topography in this area would not be conducive to supporting a reservoir. Most of the roads in this area were built recently and therefore would not have artificially created a reservoir at the date of the USGS Quad map.

The road which creates a barrier at Site A has a surface about eight feet above the low point in the arroyo. The road which creates a barrier at Sites B1 & B2 has a surface about three feet above the low point of the arroyo on the east and five feet above the low point of the arroyo on the west. Site C has a surface about five feet above the low point in the arroyo. See attached photoplates for Site locations and additional detail.

If you have any questions regarding this report, or need further information, please contact Kristie Achee or Joe Baiza at (661) 616-2600.

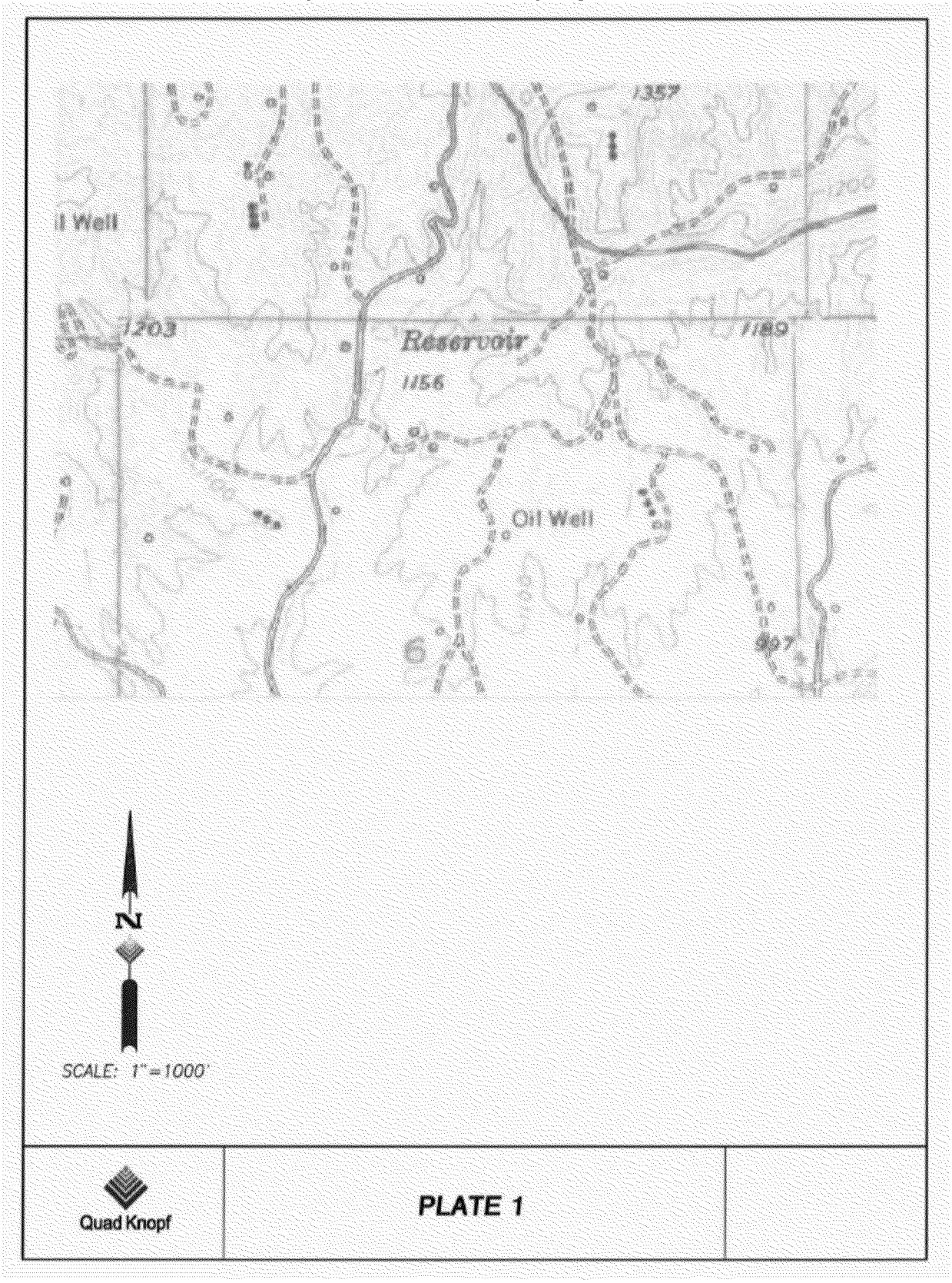
Quad Knopf, Inc

Kristie Achee, PLS
Survey Department Manager

5080 California Avenue, Suite 220, Bakersfield, CA 93309 • Tel (661) 616-2600 • Fax (661) 616-5970

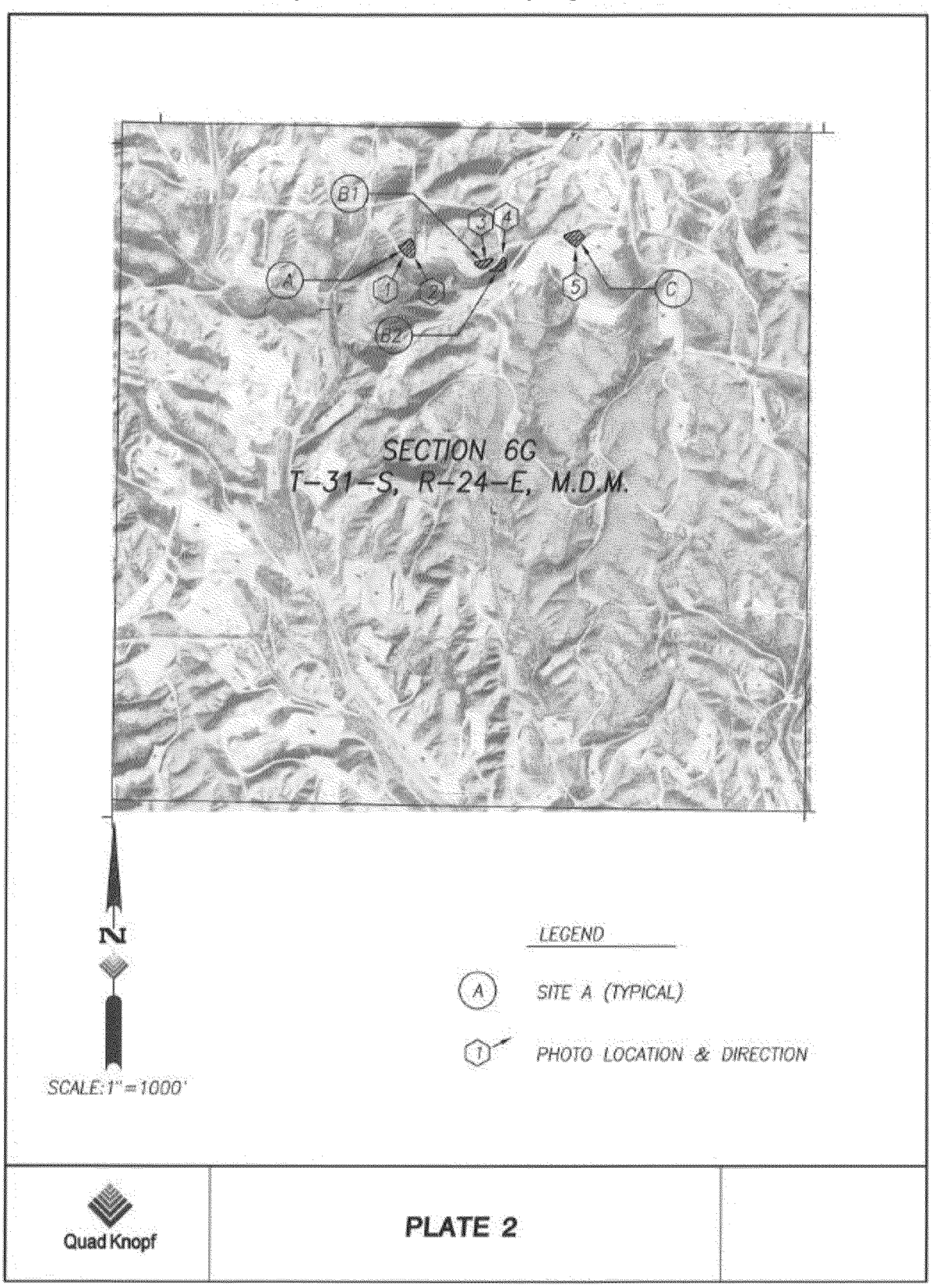
Cover letter for field reconnaissance findings for the potential reservoir conducted by Quad Knopf for the Elk Hills Power aquifer exemption

Attachment 3: Survey of Water Wells and Springs within the Area of Review



Attachment to Quad Knopf Potential Reservoir Letter

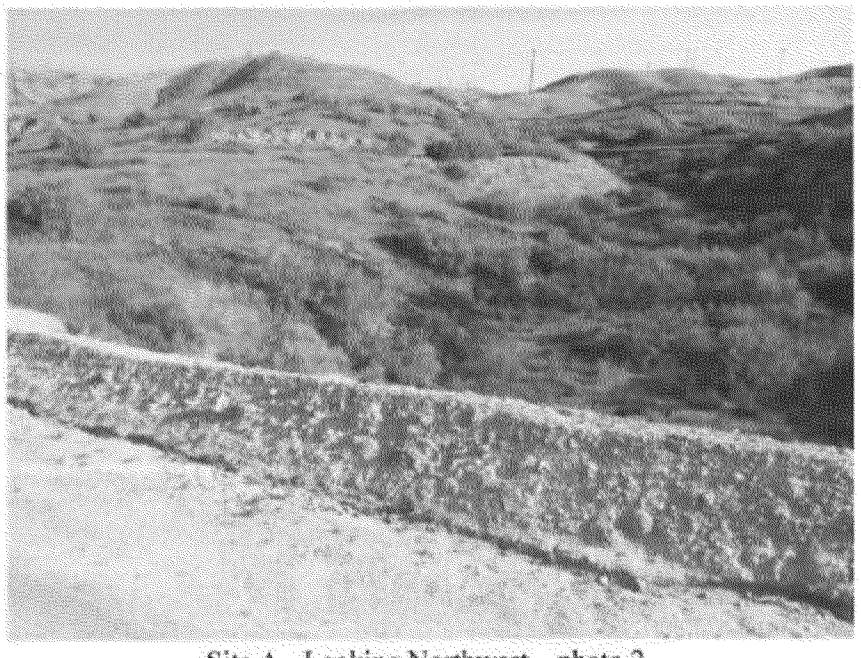
Attachment 3: Survey of Water Wells and Springs within the Area of Review



Attachment to Quad Knopf Potential Reservoir Letter

Attachment 3: Survey of Water Wells and Springs within the Area of Review

Site A - Looking Northeast – photo 1

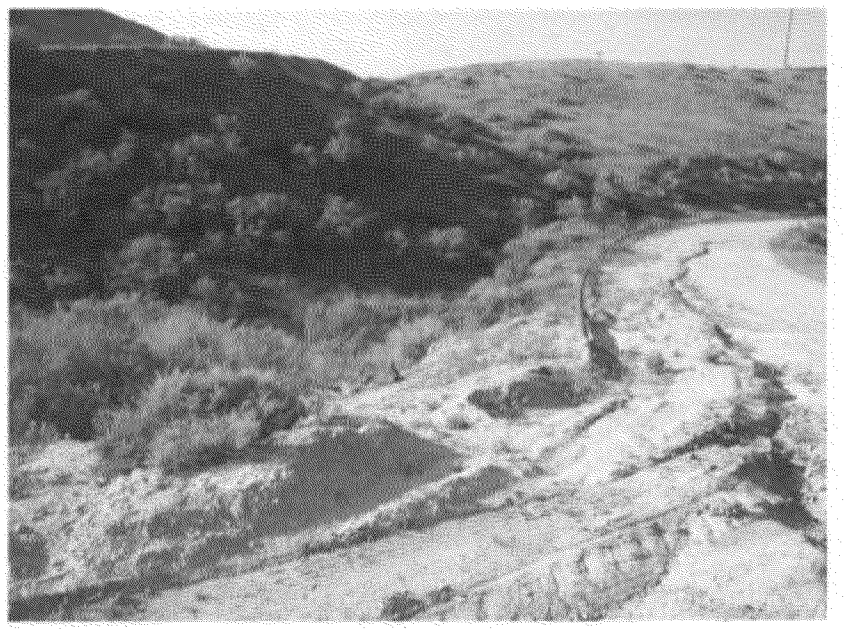


Site A - Looking Northwest – photo 2

Quad Knopf	PLATE 3	

Attachment to Quad Knopf Potential Reservoir Letter

Site B1 – Looking South – photo 3



Site B2 – Looking South – photo 4

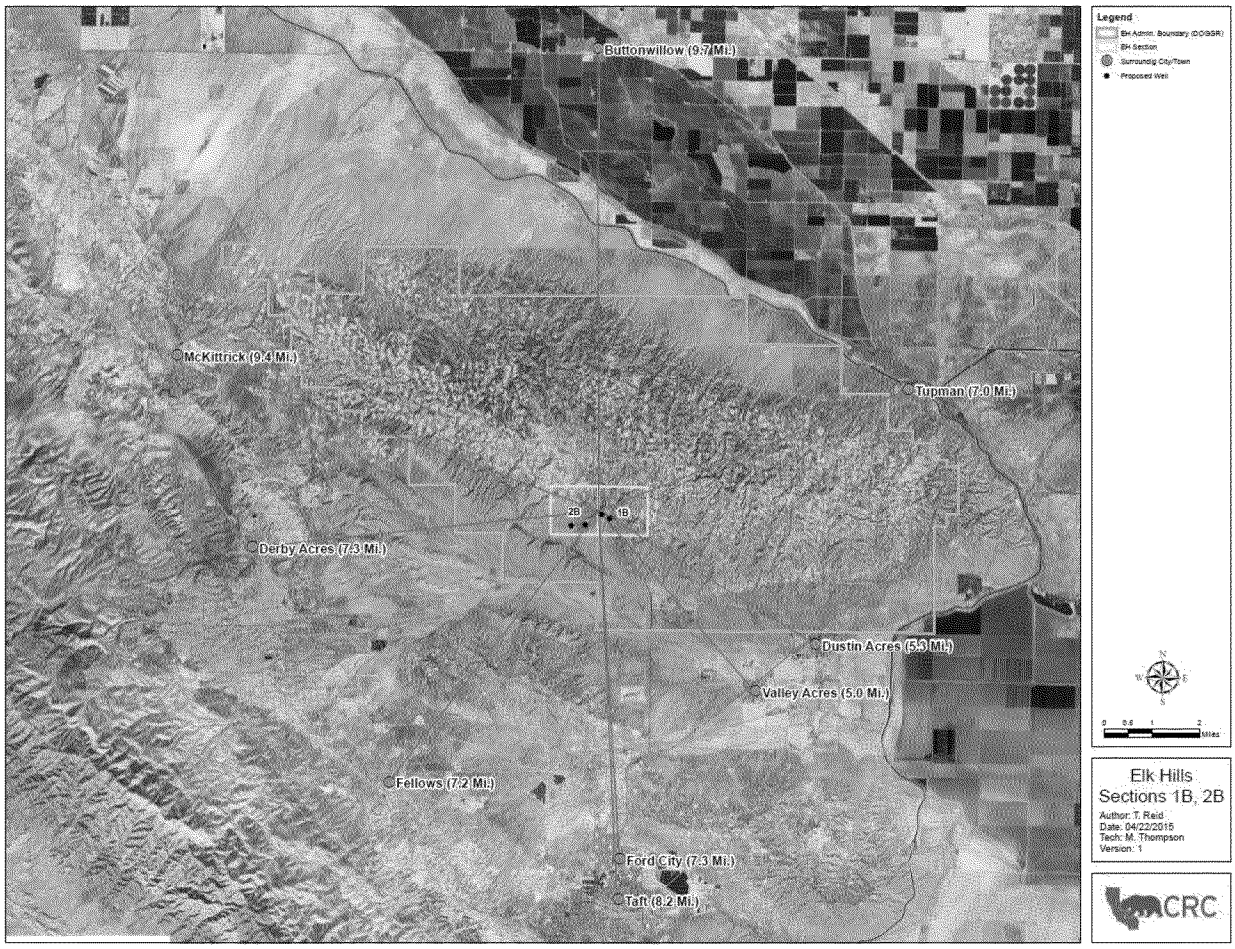
Quad Knopf	PLATE 4	

Site C – Looking North – photo 5

Quad Knopf	PLATE 5	

Attachment to Quad Knopf Potential Reservoir Letter

Attachment 4: Information on Nearby Towns

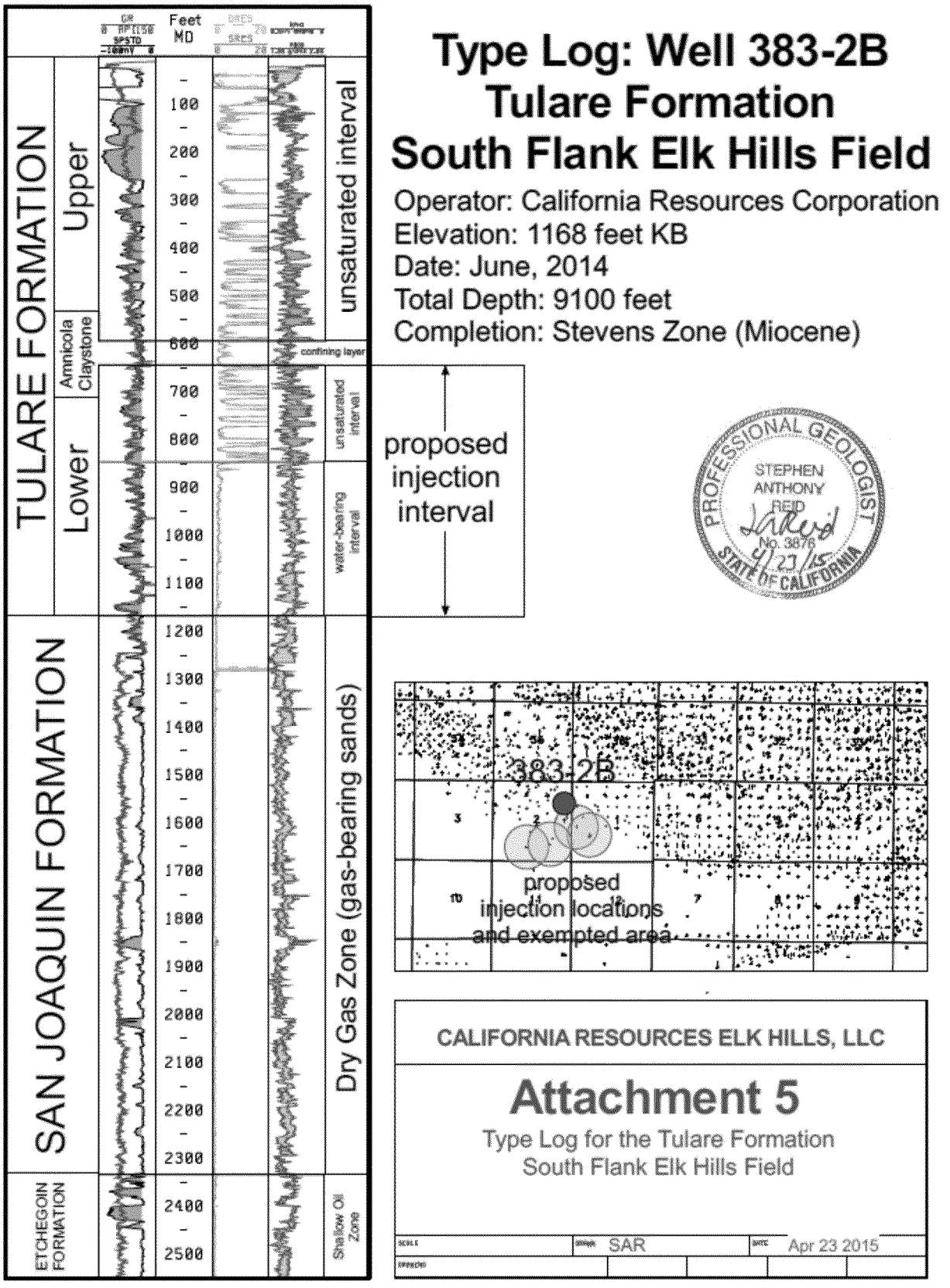


Town	Distance from 1B/2B Area	Population[13]	Rank Based on 1,523 California Cities	Population Density/Sq. Mile[2]	2010-2014 Population Growth Rate[10]	2014-2019 Population Growth Rate[14]
Valley Acres	5.0 miles	532	1,175	129	0.22%	0.48%
Dustin Acres	5.3 miles	658	1,141	179	0.22%	0.48%
Tupman	7.0 miles	162	1,378	307	0.15%	0.37%
Fellows	7.2 miles	108	1,426	165	0.44%	0.55%
Derby Acres	7.3 miles	323	1,265	90	0.07%	0.37%
Ford City	7.3 miles	4,267	684	2,781	-0.06%	0.19%
Taft	8.2 miles	9,088	506	601	-0.61%	0.48%
McKittrick	9.4 miles	116	1,422	44	0.2%	0.34%
Buttonwillow	9.7 miles	1,495	952	216	-0.2%	0.16%

[13] Data as of July 1, 2014. Source: California.HometownLocator.com and based on California Census.

[14] Compound annual growth rate. Source: California.HometownLocator.com.

Attachment 5: Type Log – Well 383-2B



Attachment 6: State Water Resources Control Board Concurrence with Elk Hills Tulare Aquifer Exemption

CALIFORNIA Water Boards

EDMUND G. BROWN JR. GOVERNOR

MATTHEW RODRIQUEZ SECRETARY FOR ENVIRONMENTAL PROTECTION

State Water Resources Control Board

FEB 11 2015

Steven R. Bohlen, State Oil & Gas Supervisor
Department of Conservation
Division of Oil, Gas & Geothermal Resources
801 K Street, MS 18-05
Sacramento, CA 95814-3530
steven.bohlen@conservation.ca.gov

Dear Mr. Bohlen:

COMMENTS ON THE OCCIDENTAL OF ELK HILLS, INC. TULARE AQUIFER EXEMPTION DOCUMENT, ELKS HILLS FIELD

State Water Resources Control Board staff, in consultation with the Central Valley Regional Water Quality Control Board staff (collectively Water Boards), have reviewed the Occidental of Elk Hills, Inc., Tulare Aquifer Exemption Document, Elk Hills Field (Exemption Request), dated September 14, 2014. The Exemption Request, forwarded to Water Board staff on October 24, 2014, proposes an aquifer exemption for the entire saturated upper Tulare zone and both the unsaturated and saturated lower Tulare zone below the Amnicola claystone within an area of approximately 59 square miles, or about 80 percent of the Elk Hills field (See Attachment 1).

Based on the information provided, Water Boards staff concur with the Exemption Request only for the following areas: All of Sections 32R and 33R in Township 30S, Range 23E; and 1B, 2B, 3B, 4B, 10B, 11B, 12B, and 13B in Township 31S, Range 23E (See Attachment 2). However, this determination will be reevaluated if future information becomes available.

State Water Boards staff do not concur with the Exemption Request for the remaining areas at this time in part due to the lack of a sufficient demonstration that the injection fluid will be confined to the intended zone or zones of injection. As a result, additional information is recommended for the remaining portions of the Exemption Request (See Attachment 3).

If you have any questions regarding this matter, please contact Mr. John Borkovich at (916) 341-5779 or john.borkovich@waterboards.ca.gov.

Sincerely,

Jonathan Bishop
Chief Deputy Director

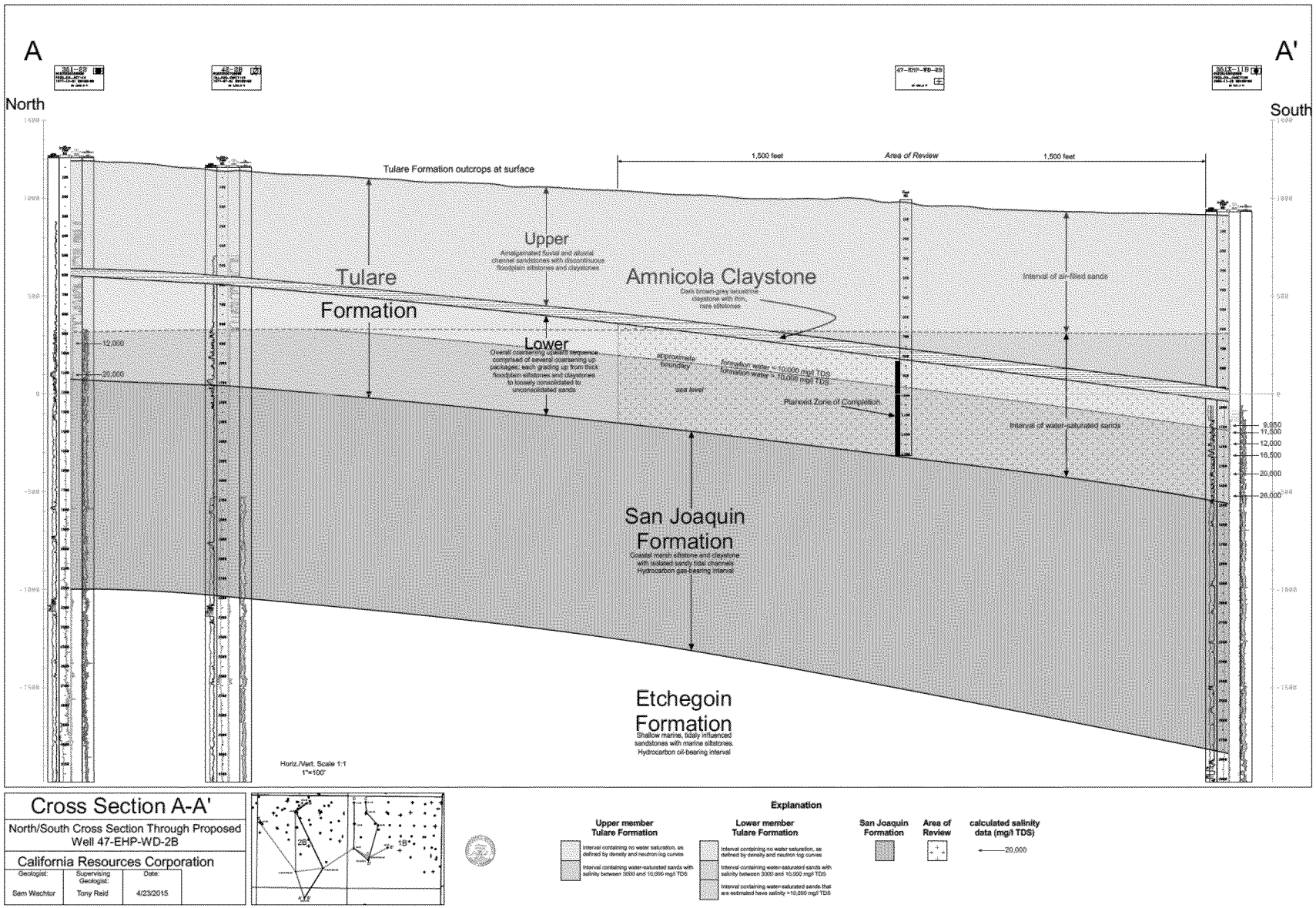
Attachments (3)

FELICIA MARCUS, CHAIR | THOMAS HOWARD, EXECUTIVE DIRECTOR

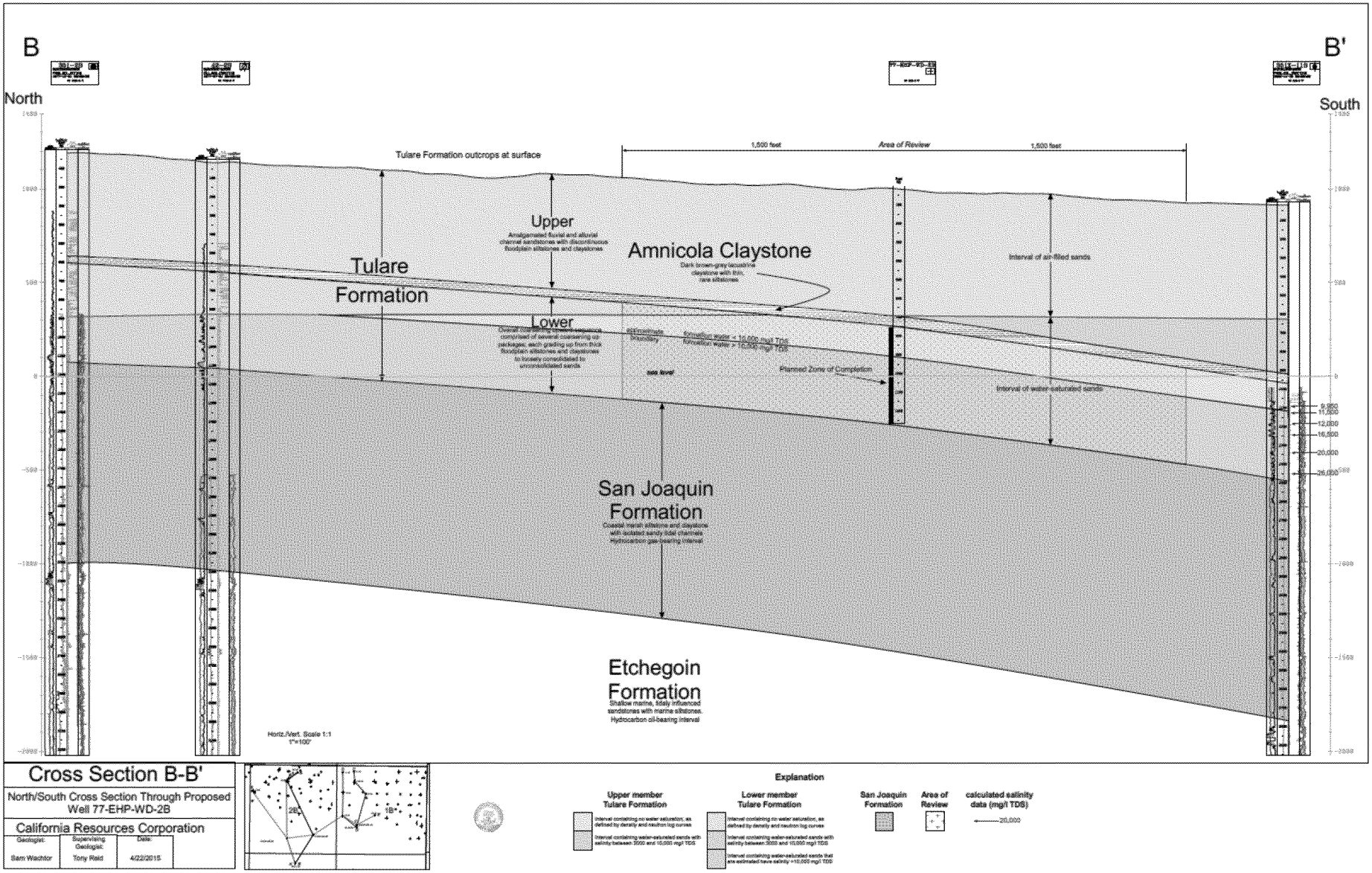
1001 I Street, Sacramento, CA 95814 | Mailing Address: P.O. Box 100, Sacramento, Ca 95812-0100 | www.waterboards.ca.gov

RECYCLED PAPER

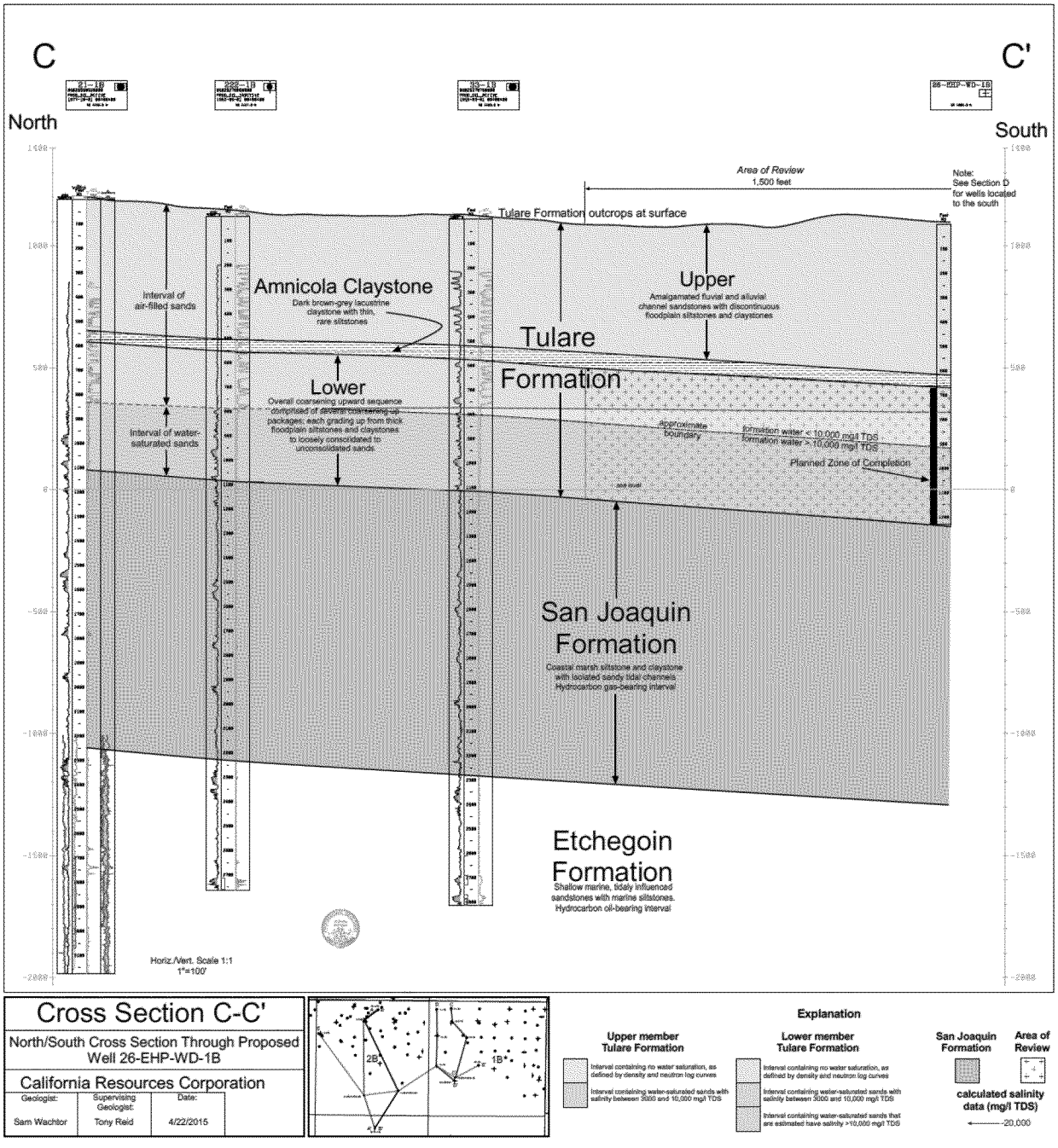
Attachment 7a: North-South Cross-Section through Proposed Well 47-EHP-WD-2B



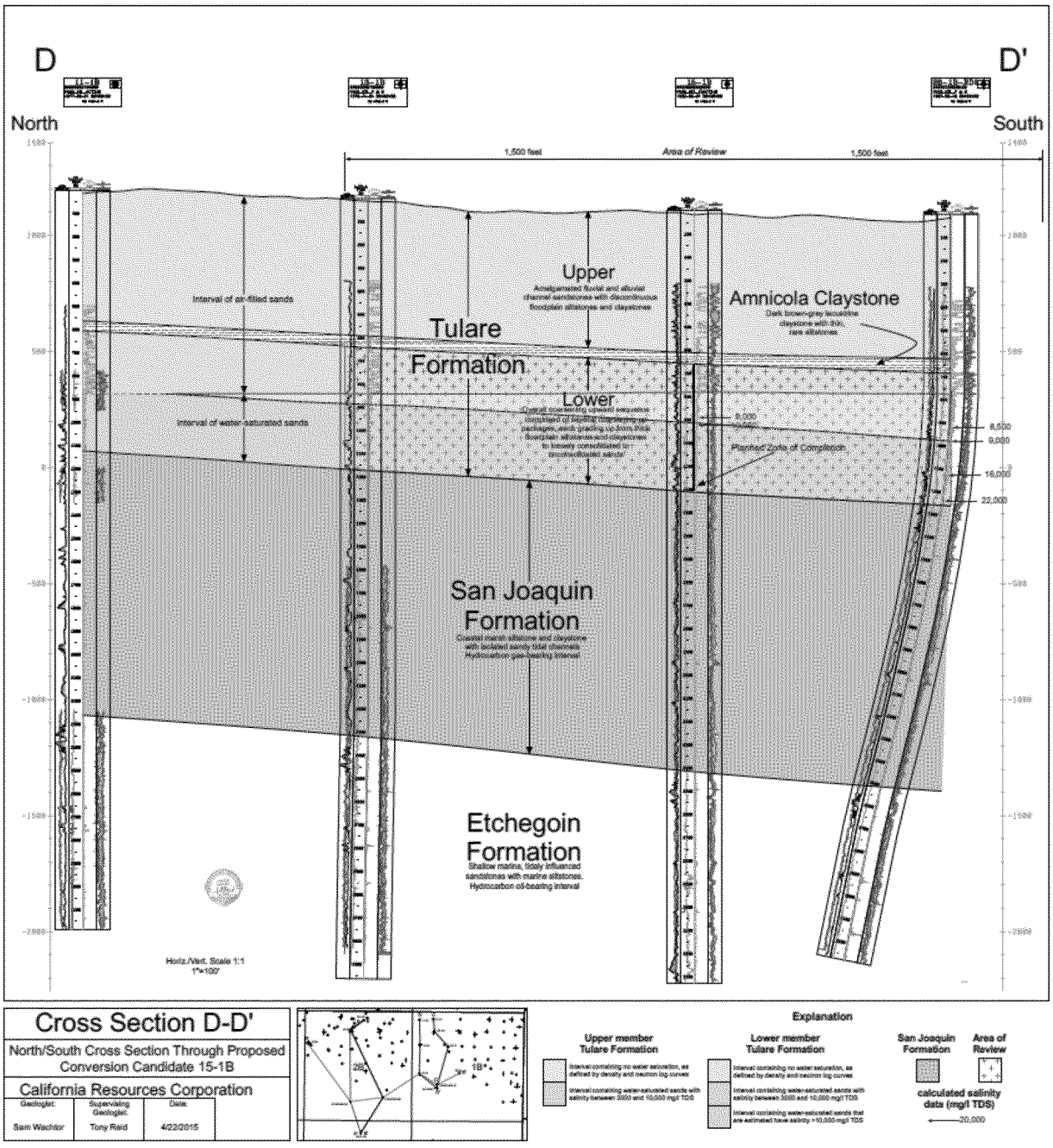
Attachment 7b: North-South Cross-Section through Proposed Well 77-EHP-WD-2B



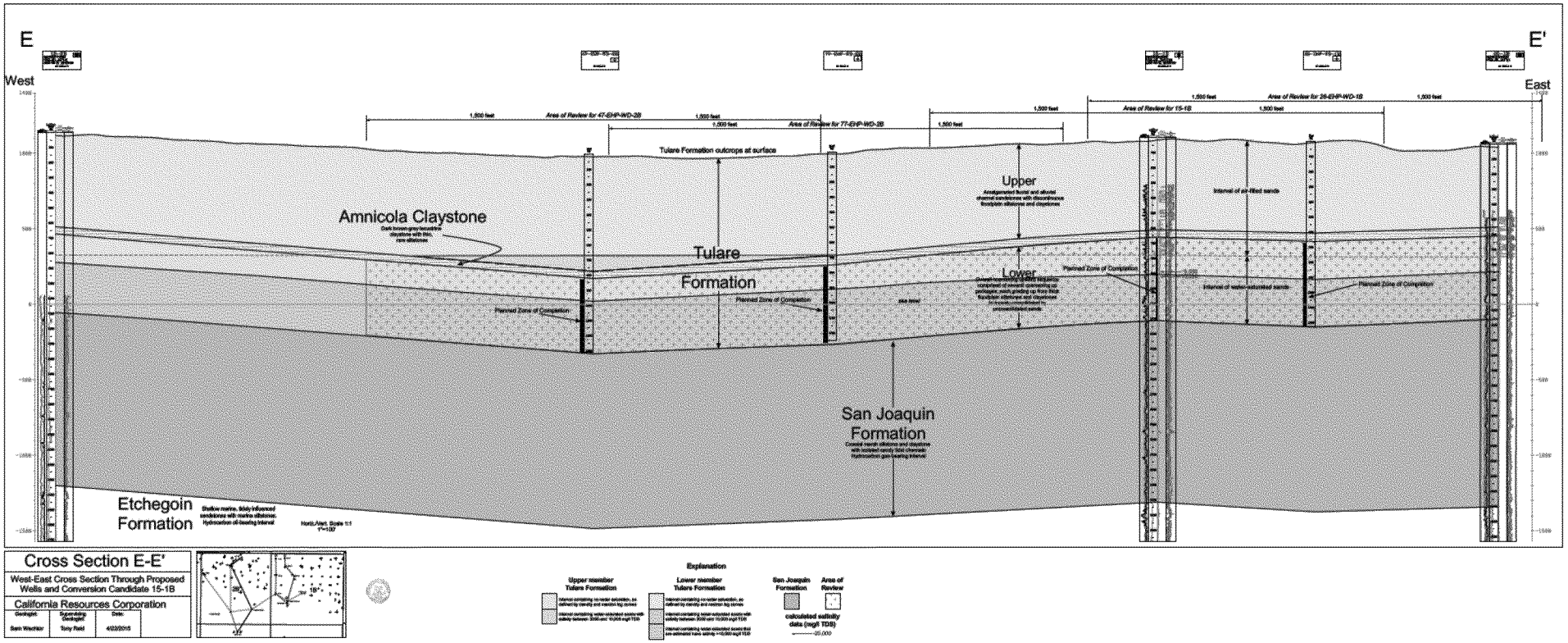
Attachment 7c: North-South Cross-Section through Proposed Well 26-EHP-WD-1B



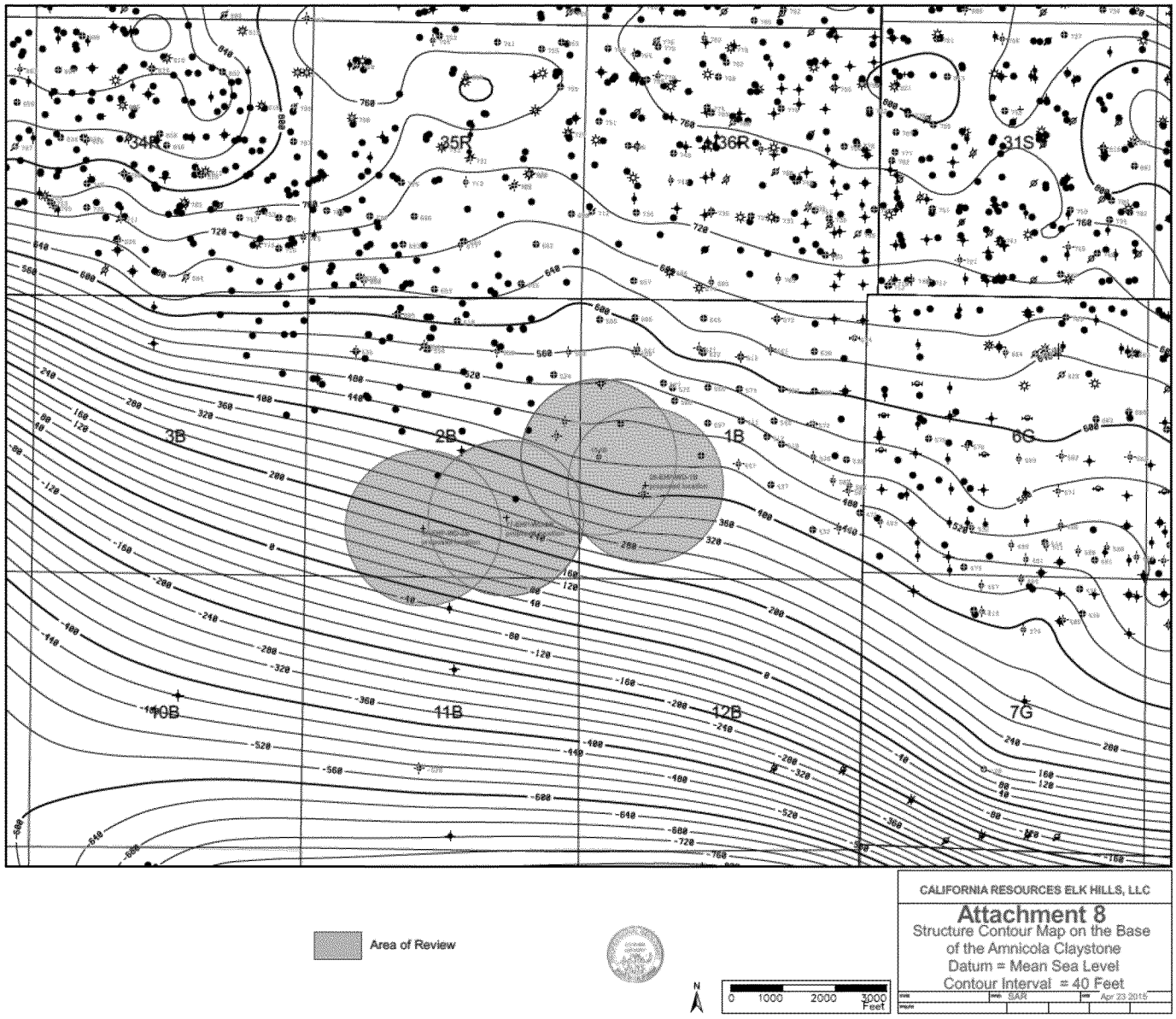
Attachment 7d: North-South Cross-Section through Conversion Candidate Well 15-1B



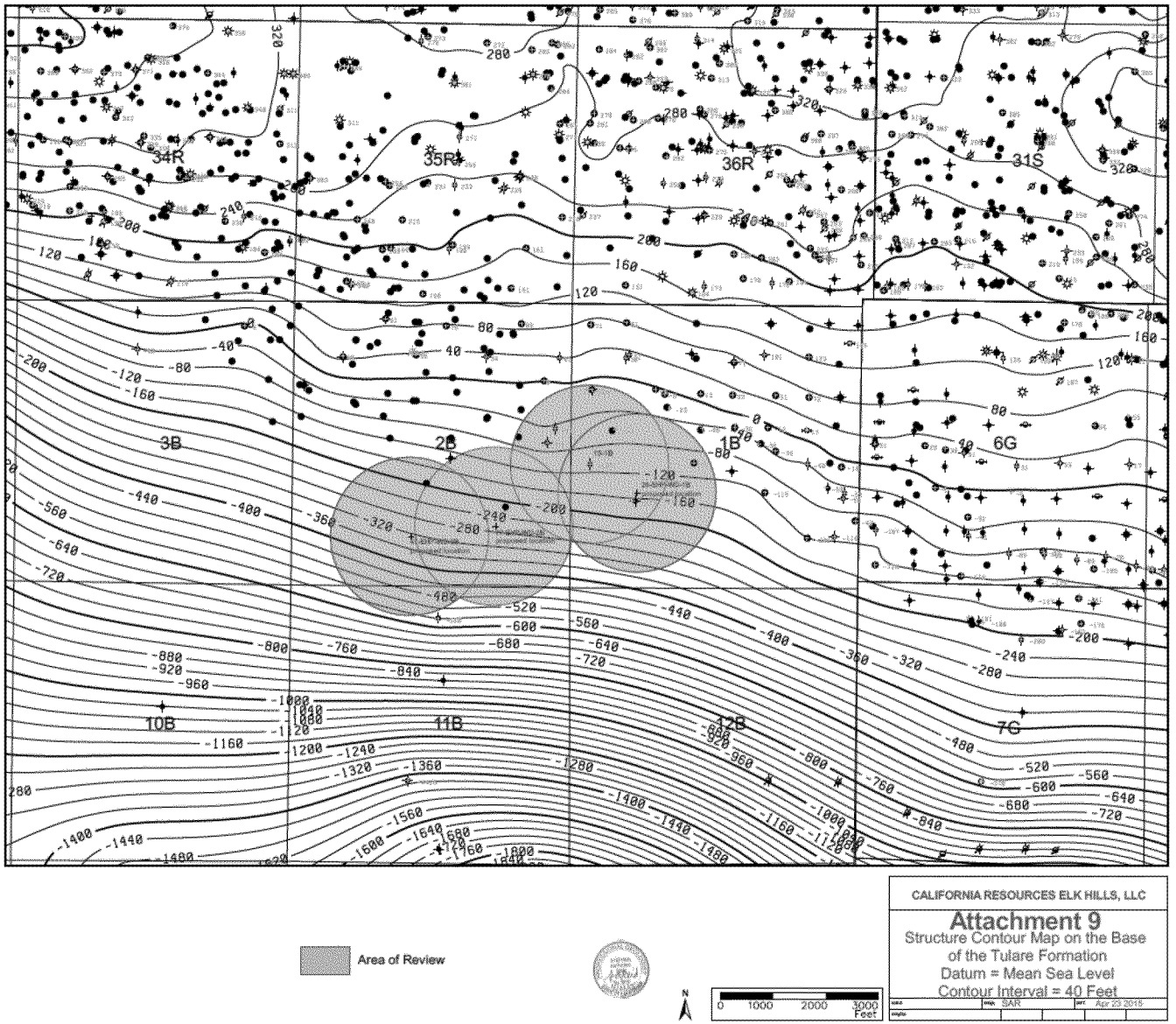
Attachment 7e: West-East Cross-Section through All Three Proposed Wells and Conversion Candidate



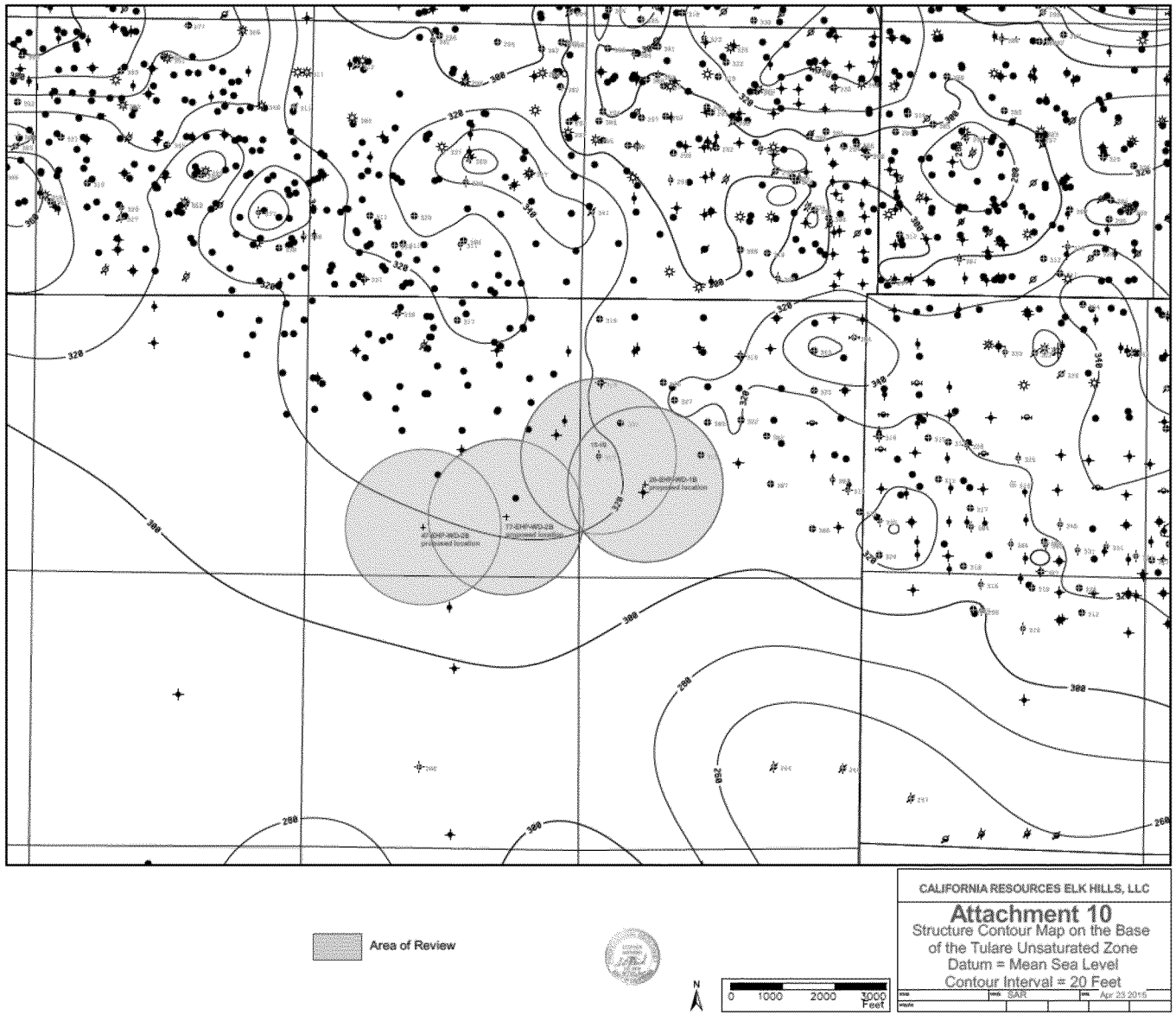
Attachment 8: Structure Contour Map on the Base of the Amnicola Claystone



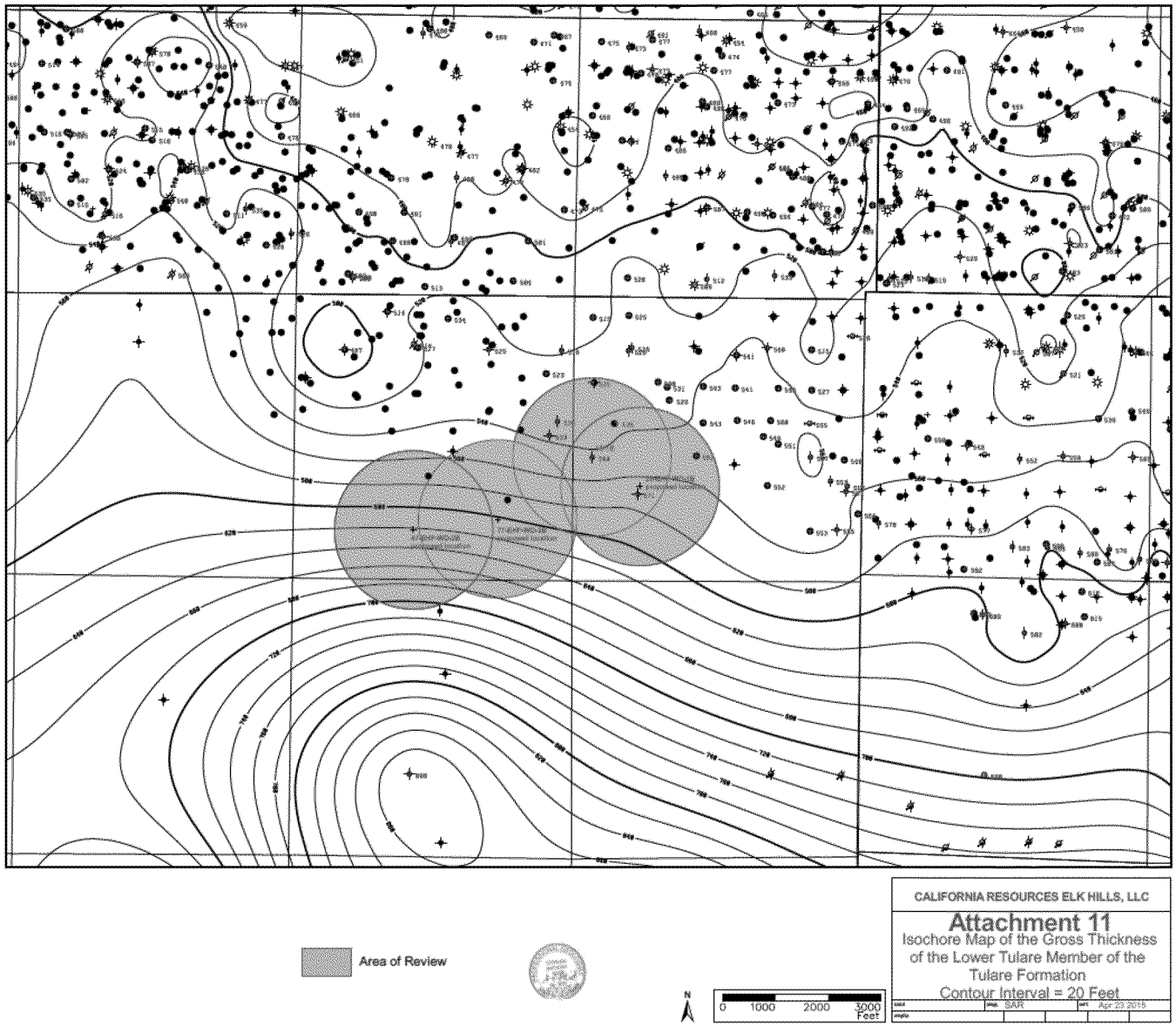
Attachment 9: Structure Contour Map on the Base of the Tulare Formation



Attachment 10: Structure Contour Map on the Base of the Tulare Unsaturated Zone



Attachment 11: Isochore Map of the Gross Thickness of the Lower Tulare Formation

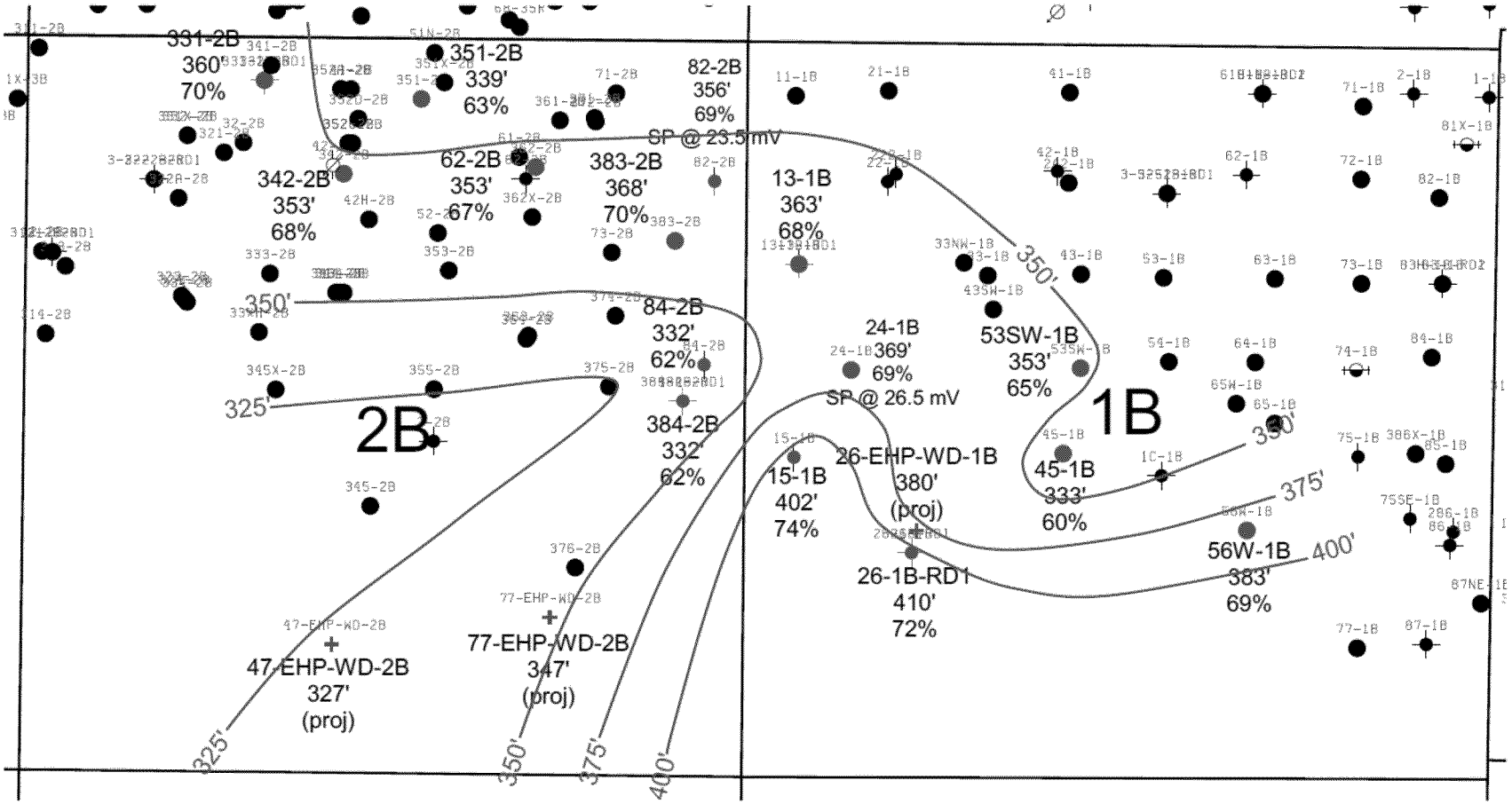


Attachment 12: Isochore Map of the Net Sand Thickness of the Lower Tulare Member of the Tulare Formation, Including Method of Lower Tulare Net Sand Estimation

Method of Lower Tulare Net Sand Estimation

The Spontaneous Potential (SP) log is used to estimate the amount of sand present in each well across the study area. The SP cut-off value is established from core samples in well 1CH-27R. Nearly the entire Lower Tulare interval was cored, and 36.5 percent of the interval is sand (Attachment 17; Attachment 20). The sand intervals in well 1CH-27R correspond to SP values less than -25.00 mv. Intervals greater than -25.00 mv are clay and silt intervals. Using the SP log, total sand is 38.5 percent of the cored interval. The SP log with a cut-off value of -25 mv is an adequate representation of the sand present and is used in the study area to determine the net sand present in the Lower Tulare. Only two wells yield anomalous net sand thickness using -25 mv and the cut-off values for these two wells were modified to be more consistent with offset wells. For well 82-2B, at cut-off value to -23.5 mv is used, and for well 24-1B a value of -26.5 mv is used.

Attachment 12: Isochore Map of the Net Sand Thickness of the Lower Tulare Member of the Tulare Formation, Including Method of Lower Tulare Net Sand Estimation



Note: data only for wells in red; other wells lack data across the Tulare interval

N

0 1000 2000 3000 Feet

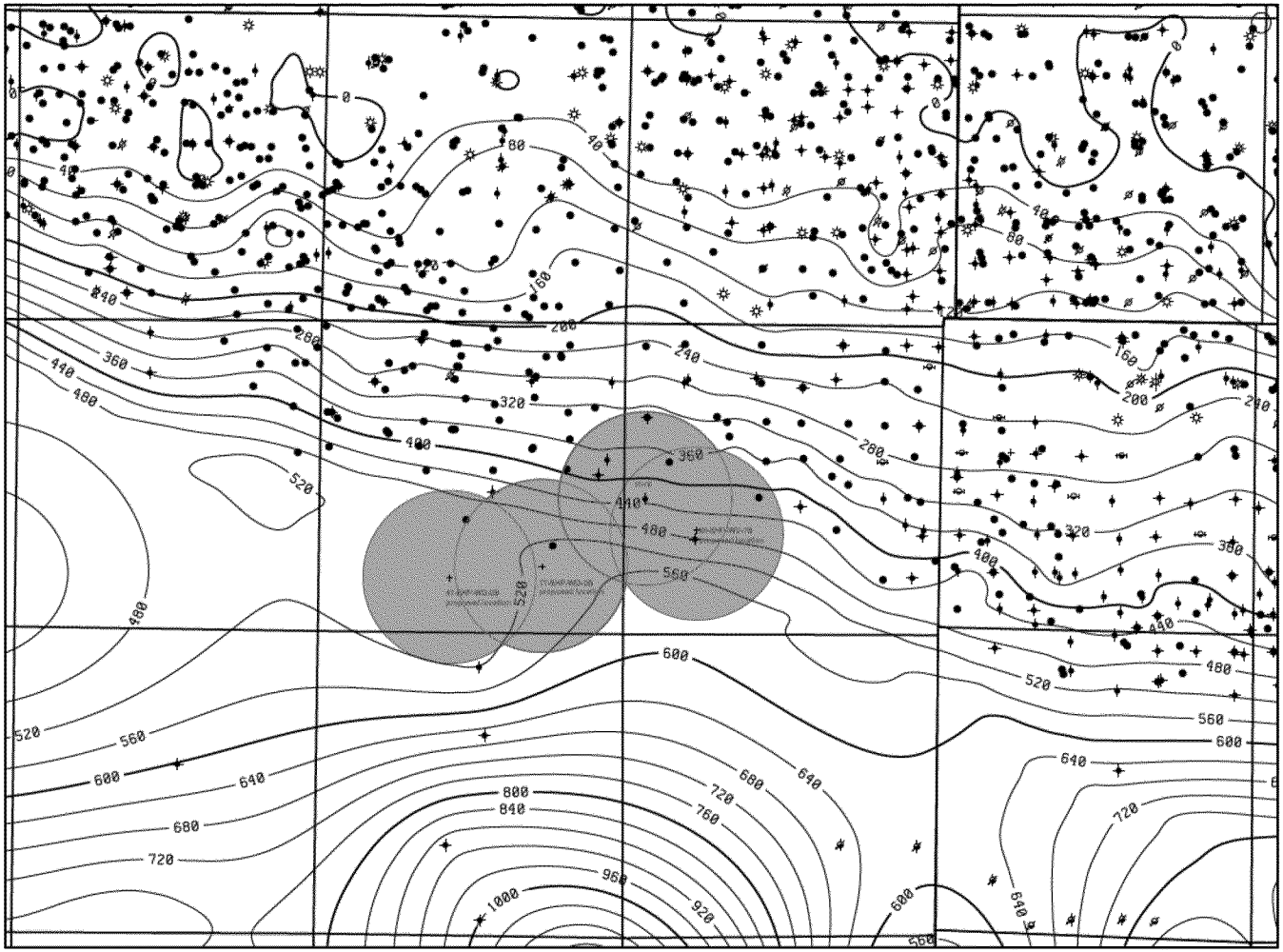
CALIFORNIA RESOURCES ELK HILLS, LLC

Attachment 12

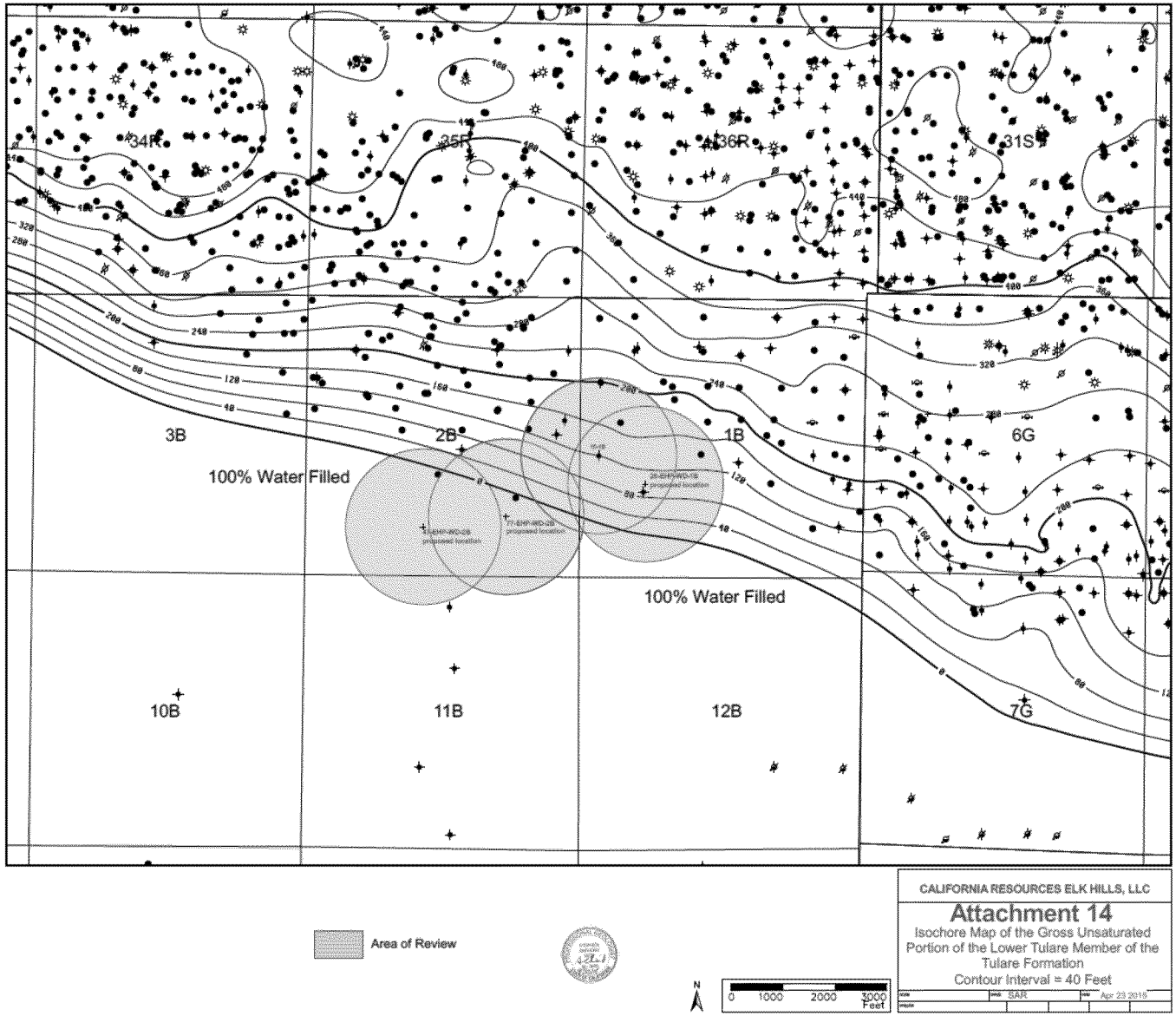
Net Sand (TVT) & Net Sand Percentage of the Lower Tulare Mbr of the Tulare Formation, Derived From Spontaneous Potential (SP) Log
Net Sand Contour Interval 25'

SCALE | DRAWN: SAR | DATE: Apr 23 2015

Attachment 13: Isopach Map of the Saturated Thickness of the Lower Tulare Member of the Tulare Formation



Attachment 14: Isochore Map of the Unsaturated Thickness of the Lower Tulare Member of the Tulare Formation



Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

BC Laboratories, Inc.
Environmental Testing Laboratory Since 1949

Occidental of Elk Hills
10800 Stockdale Hwy
Bakersfield, CA 93311

Reported: 06/05/2014 13:04
Project: SB4 Sampling
Project Number: SB4
Project Manager: Aaron Barbie

Water Analysis (General Chemistry)

BCL Sample ID: 1411084-01 | Client Sample Name: Elk Hills Well 82-2B, 5/17/2014 4:05:00PM, Rick Ogletree

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Electrical Conductivity @ 25 C (Field Test)	27000	umhos/cm	1.0	1.0	EPA-120.1			1
pH (Field Test)	7.23	pH Units	0.05	0.05	EPA-150.1			2
Temperature (Field Test)	67.6	F	32.0	32.0	SM-2550B			3
Total Calcium	650	mg/L	2.0	0.30	EPA-6010B	ND	A10	4
Total Magnesium	230	mg/L	1.0	0.38	EPA-6010B	0.75	A10	4
Total Sodium	4700	mg/L	10	1.0	EPA-6010B	ND	A01	4
Total Potassium	31	mg/L	20	2.6	EPA-6010B	ND	A10	4
Bicarbonate Alkalinity as CaCO3	59	mg/L	8.2	8.2	EPA-310.1	ND		5
Carbonate Alkalinity as CaCO3	ND	mg/L	8.2	8.2	EPA-310.1	ND		5
Hydroxide Alkalinity as CaCO3	ND	mg/L	8.2	8.2	EPA-310.1	ND		5
Total Alkalinity as CaCO3	59	mg/L	8.2	8.2	EPA-310.1	ND		5
Bromide	50	mg/L	5.0	2.2	EPA-300.0	ND	A01	6
Chloride	10000	mg/L	50	6.7	EPA-300.0	20	A01	7
Fluoride	ND	mg/L	2.5	0.70	EPA-300.0	ND	A10	6
Nitrate as NO3	ND	mg/L	22	5.5	EPA-300.0	ND	A10	6
Sulfate	320	mg/L	50	9.0	EPA-300.0	19	A01	6
pH	7.47	pH Units	0.05	0.05	EPA-150.1		S05	8
Electrical Conductivity @ 25 C	26100	umhos/cm	1.00	1.00	EPA-120.1			9
Total Dissolved Solids @ 180 C	20000	mg/L	1000	1000	EPA-160.1	ND		10

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-120.1	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
2	EPA-150.1	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
3	SM-2550B	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
4	EPA-6010B	05/23/14	05/27/14 12:45	ARD	PE-OP2	20	BXE2073
5	EPA-310.1	05/20/14	05/20/14 22:52	RML	MET-1	2	BXE1764
6	EPA-300.0	05/19/14	05/19/14 15:23	LD1	IC5	50	BXE1561
7	EPA-300.0	05/19/14	05/19/14 15:36	OLH	IC5	100	BXE1561
8	EPA-150.1	05/20/14	05/20/14 22:52	RML	MET-1	1	BXE1764
9	EPA-120.1	05/20/14	05/20/14 22:52	RML	MET-1	1	BXE1764
10	EPA-160.1	05/20/14	05/20/14 14:00	FRP	MANUAL	100	BXE1775

Lower Tulare Groundwater Analyses for the 82-2B Well

Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

BC Laboratories, Inc.
Environmental Testing Laboratory Since 1949

Occidental of Elk Hills
10800 Stockdale Hwy
Bakersfield, CA 93311

Reported: 06/05/2014 13:04
Project: SB4 Sampling
Project Number: SB4
Project Manager: Aaron Barbie

Metals Analysis

BCL Sample ID: 1411084-01 | **Client Sample Name:** Elk Hills Well 82-2B, 5/17/2014 4:05:00PM, Rick Ogletree

Constituent	Result	Units	PQL	MDL	Method	TTLC Limits	Lab Quals	Run #
Hexavalent Chromium	ND	ug/L	2.0	0.70	EPA-7196		A26,S05	1
Total Antimony	ND	ug/L	2000	170	EPA-6010B	500000	A10	2
Total Arsenic	ND	ug/L	1000	160	EPA-6010B	500000	A10	2
Total Barium	**560**	**ug/L**	**200**	**70**	**EPA-6010B**	10000000	A10	2
Total Beryllium	ND	ug/L	200	10	EPA-6010B	75000	A10	2
Total Boron	**5.7**	**mg/L**	**2.0**	**0.26**	**EPA-6010B**		A10	2
Total Cadmium	ND	ug/L	200	22	EPA-6010B	100000	A10	2
Total Chromium	ND	ug/L	200	22	EPA-6010B	2500000	A10	2
Total Cobalt	ND	ug/L	1000	26	EPA-6010B	8000000	A10	2
Total Copper	ND	ug/L	200	22	EPA-6010B	2500000	A10	2
Total Lead	ND	ug/L	1000	80	EPA-6010B	1000000	A10	2
Total Lithium	**1.2**	**mg/L**	**0.40**	**0.12**	**EPA-6010B**		A10	2
Total Mercury	ND	ug/L	2.0	0.24	EPA-7470A	20000	A10	3
Total Molybdenum	ND	ug/L	1000	24	EPA-6010B	3500000	A10	2
Total Nickel	**67**	**ug/L**	**200**	**40**	**EPA-6010B**	2000000	J,A10	2
Total Selenium	**720**	**ug/L**	**2000**	**300**	**EPA-6010B**	100000	J,A10	2
Total Silver	ND	ug/L	200	38	EPA-6010B	500000	A10	2
Total Strontium	**17**	**mg/L**	**0.20**	**0.020**	**EPA-6010B**		A01	2
Total Thallium	ND	ug/L	2000	480	EPA-6010B	700000	A10	2
Total Vanadium	ND	ug/L	200	44	EPA-6010B	2400000	A10	2
Total Zinc	**45**	**ug/L**	**1000**	**46**	**EPA-6010B**	5000000	J,A10	2
Total Recoverable Uranium	ND	pCi/L	3.4	0.34	EPA-200.8		A10	4

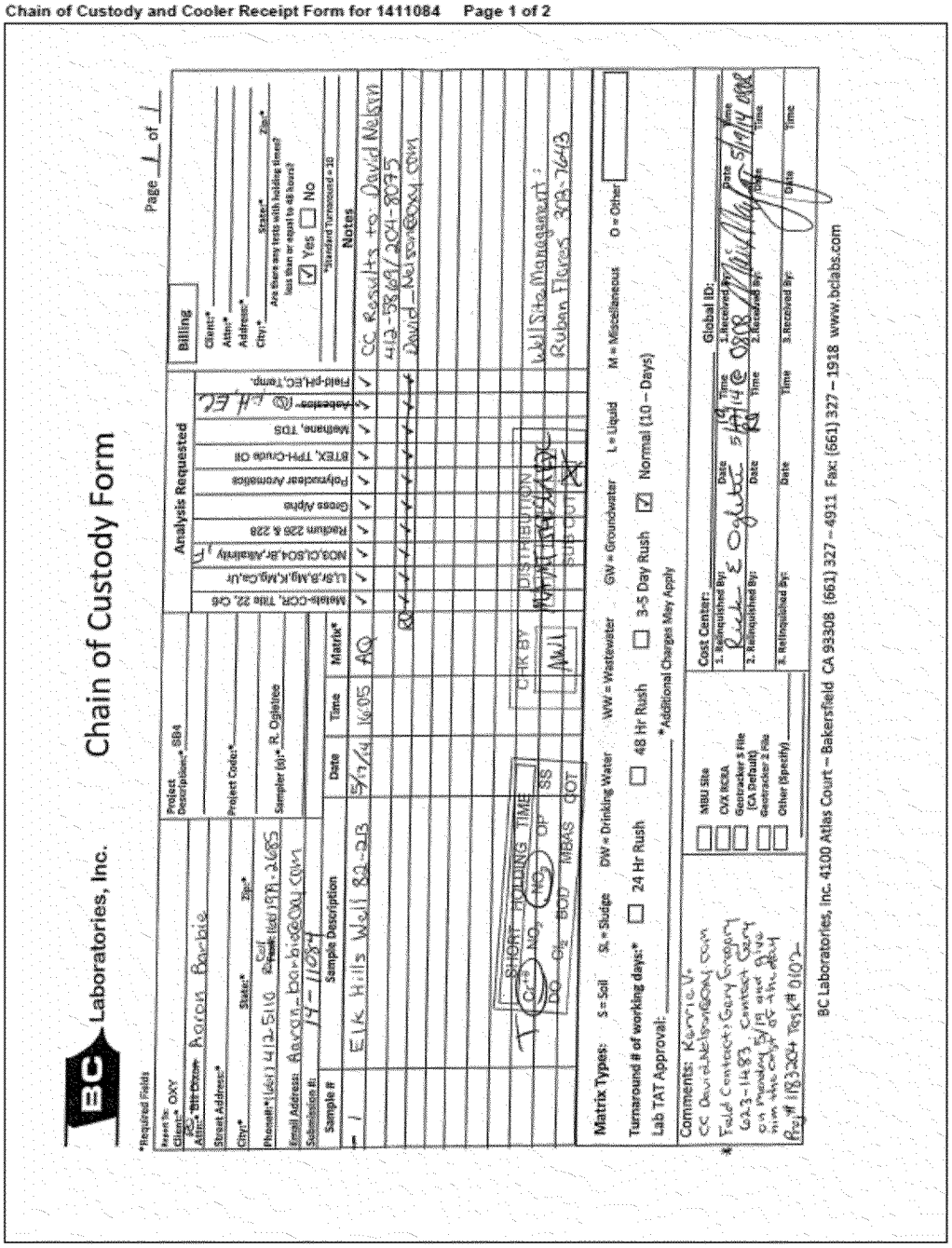
Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-7196	05/19/14	05/19/14 11:17	TDC	KONE-1	1	BXE1721
2	EPA-6010B	05/23/14	05/27/14 12:45	ARD	PE-OP2	20	BXE2073
3	EPA-7470A	05/27/14	05/29/14 14:17	MEV	CETAC1	10	BXE2194
4	EPA-200.8	05/28/14	05/29/14 11:00	EAR	PE-EL2	5	BXE2298

Lower Tulare Groundwater Analyses for the 82-2B Well

Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

BC Laboratories, Inc.
Environmental Testing Laboratory Since 1949

Chain of Custody and Cooler Receipt Form for 1411084 Page 1 of 2



Chain-of-Custody Form for the 82-2B Groundwater Sample

BC Laboratories, Inc.
Environmental Testing Laboratory Since 1949

Subcontract Report for 1411084 PDF File Name: WO_1411084_SUB_BSKSA.pdf Page 8 of 8

BSK Associates SR FL 0002-09

A4E1694 05/20/2014
BCLab4911 9

Sample Integrity

BSK Bottles: Yes (No) Page 1 of 1

COC Info				
Was temperature within range? Chemistry ≤ 6°C Micro < 10°C	(Yes) No NA	Were correct containers and preservatives received for the tests requested?	(Yes) No NA
If samples were taken today, is there evidence that chilling has begun?	Yes No (NA)	Were there bubbles in the VOA vials? (Volatiles Only)	Yes No (NA)
Did all bottles arrive unbroken and intact?	(Yes) No	Was a sufficient amount of sample received?	(Yes) No
Did all bottle labels agree with COC?	(Yes) No	Do samples have a hold time <72 hours?	Yes (No)
Was sodium thiosulfate added to CN sample(s) until chlorine was no longer present?	Yes No (NA)	Was PM notified of discrepancies? PM: By/Time:	Yes No (NA)

Bottles Received ("" means preservation/chlorine checks are either N/A or are performed in the lab)	250ml(A) 500ml(B) 1Liter(C) 40ml VOA(V)	Checks	Passed?
	Bacti $Na_2S_2O_3$	—	—
	None (P) White Cap	—	—
	Cr6 Buffer (P) Blue Cap	pH 9-9.5	Y N
	HNO_3 (P) Red Cap	—	—
	H_2SO_4 (P) Yellow Cap	pH ≤ 2	Y N
	NaOH (P) Green Cap	Cl, pH ≥12	Y N
	NaOH + ZnAc (P)	pH ≥ 9	Y N
	Dissolved Oxygen 300ml (g)	—	—
	None (AG) 608/8081/8082, 625, 632/8321, 8151, 8270	—	—
	H_2SO_4 (AG) Yellow Label O&G, Diesel	—	—
	$Na_2S_2O_3$ 1 Liter (Brown P) 549	—	—
	$Na_2S_2O_3$ (AG) Blue Label 547, 515, 525, 548	—	—
	$Na_2S_2O_3$ (AG) Blue Label THMs 524.2 or 524.3	—	—
	$Na_2S_2O_3$ (CG) Blue Label 504, 505	—	—
	$Na_2S_2O_3$ + MCAA (CG) Orange Label 531	pH ≤ 3	Y N
	NH_4Cl (AG) Purple Label 552	—	—
	EDA (AG) Brown Label DBPs	—	—
	Ascorbic + Malcic (AG) Lt Green Label 524.3	—	—
	HCL (CG) 524.2,BTEX,Gas, MTBE, 8200/624	—	—
	Buffer pH 4 (CG)	—	—
	None (CG)	—	—
	H_3PO_4 (CG) Salmon Label	—	—
	Other:	—	—
	Asbestos 1Liter Plastic w/ Foil	—	—
	Low Level Hg / Metals Double Baggie	—	—
	Bottled Water	—	—
	Clear Glass Jar: 250 / 500 / 1 Liter	—	—
	Soil Tube Brass / Steel / Plastic	—	—
	Tedlar Bag / Plastic Bag	—	—

Split	Container	Preservative	Date/Time/Initials		Container	Preservative	Date/Time/Initials
S P				S P			
S P				S P			

Comments

Labeled by: [illegible] @ [illegible] Labels checked by: NR @ 1632 RUSH Paged by: @

Page 8 of 8

Sample Integrity Form for the 82-2B Groundwater Sample

Attention Mr. Jim White

48-9g

GEOCHEMICAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	6/15/78	WELL NO.	48-9G Int. 1275-1040
DATE OF SAMPLING	5/22/78	COMPANY	Williams Bros. Engineering Company
SAMPLED BY		FIELD	
LABORATORY NO.	3012	ZONE	Flowline while swabbing 5:20 pm
ANALYST		SAMPLE SOURCE	from 900'

RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM +Potassium	$Na+K$	3921.23	170.49	40.62
CALCIUM	Ca	610.	30.5	7.27
MAGNESIUM	Mg	108.	8.88	2.12
BARIUM	Ba	(-) 1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1800.	37.5	8.93
CHLORIDE	Cl	6049.5	170.89	40.72
CARBONATE	CO_3	-	-	-
BICARBONATE	HCO_3	90.1	1.48	0.35
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2			
IRON, ALUMINA	R_2O_3	68.		
TOTAL		12647.	419.7	100.00

GROUP	CHEMICAL CHARACTER		MISCELLANEOUS		
ALKALIS	PRIMARY SALINITY	81.22	BORON	9.4	PPM
EARTHS	SECONDARY SALINITY	18.08	HYDROGEN SULFIDE	less than 0.1	ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	11003	PPM
WEAK ACIDS	SECONDARY ALKALINITY	0.70	RESISTIVITY @ 77°F	0.53	O.M.
Ca/[illegible] Mg = 3.43			CHLORINITY	9980.0	PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.009	
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.5	

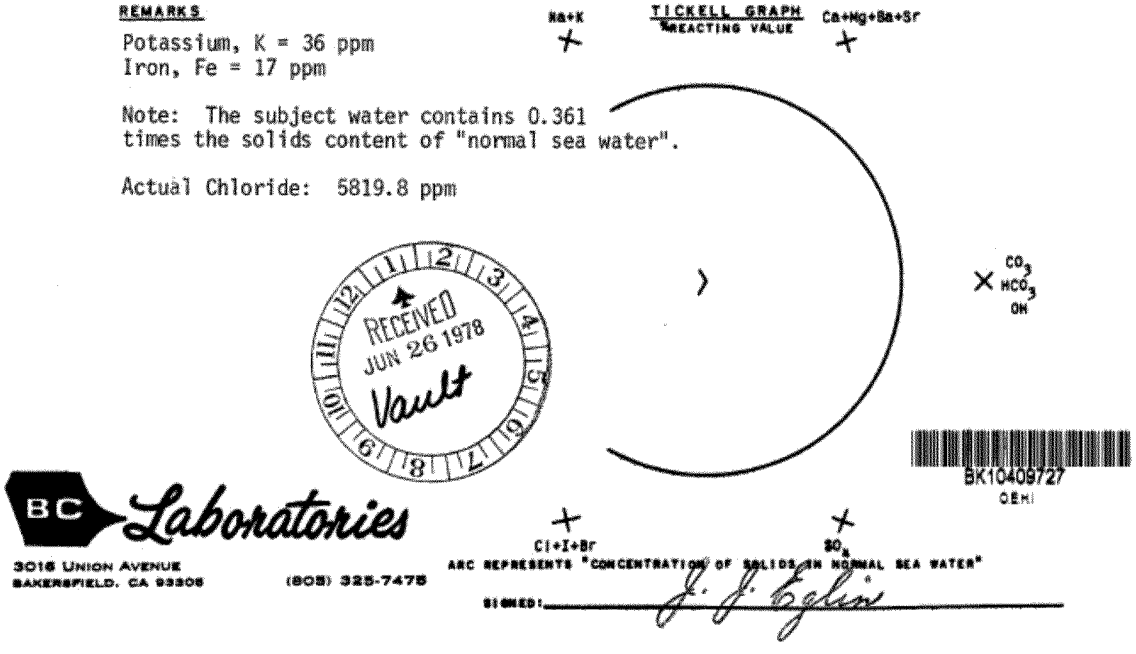
REMARKS

Potassium, K = 36 ppm
Iron, Fe = 17 ppm

Note: The subject water contains 0.361 times the solids content of "normal sea water".

Actual Chloride: 5819.8 ppm

TICKELL GRAPH %REACTING VALUE



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BK10409727 OEHI

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3016 UNION AVENUE
BAKERSFIELD, CA 93305
(805) 325-7475

ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

SIGNED: J. J. Eglin

Groundwater Analyses for the 48-9G in the Lower Tulare Interval from 1,040 to 1,260 Feet

Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

Attention Mr. Jim White

GEOCHEMICAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	6/22/78	WELL NO.	48-9G Int. 1265'-1040' Flowline
DATE OF SAMPLING		COMPANY	Williams Bros. Engineering Company
SAMPLED BY	5/23/78	FIELD	
LABORATORY NO.	4042	ZONE	Swabbing 5:25 pm form 900'
ANALYST		SAMPLE SOURCE	

RADICALS		PARTS PER MILLION (MILLIGRAMS PER LITER)	REACTING VALUE (EQUIVALENTS PER MILLION)	REACTING VALUE (PERCENT)
SODIUM+Potassium	$Na+K$	3264.2	141.92	39.54
CALCIUM	Ca	568.	28.40	7.91
MAGNESIUM	Mg	94.0	7.73	2.15
BARIUM	Ba	less than 1.		
STRONTIUM	Sr			
Iron	Fe	37.0	1.42	0.40
SULPHATE	SO_4	2016.	42.0	11.70
CHLORIDE	Cl	4816.2	136.05	37.90
CARBONATE	CO_3	-	-	
BICARBONATE	HCO_3	86.6	1.42	0.40
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	80.		
IRON, ALUMINA	R_2O_3			
TOTAL		10062.	358.8	100.00

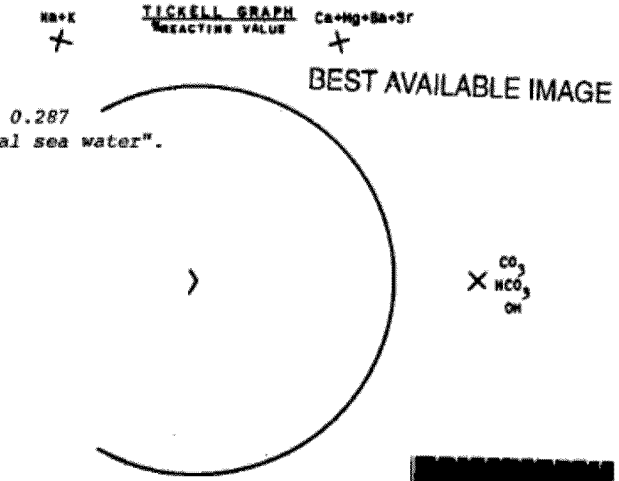
GROUP	CHEMICAL CHARACTER		MISCELLANEOUS		
ALKALIS	PRIMARY SALINITY	79.08	BORON	6.0	PPM
EARTHS	SECONDARY SALINITY	20.12	HYDROGEN SULFIDE	less than 0.1	ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	8970	PPM
WEAK ACIDS	SECONDARY ALKALINITY	0.80	RESISTIVITY @ 77°F	0.65	O.M.
Ca/~~Carbs~~ Mg = 3.67			CHLORINITY	7945	PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.007	
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH 7.3		

REMARKS

Potassium, K = 24 ppm
Iron, Fe = 37 ppm

Note: The subject water contains 0.287 times the solids content of "normal sea water".

TICKELL GRAPH (REACTING VALUE)



BEST AVAILABLE IMAGE

[redacted] BK1[redacted]

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(805) 325-7478

ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

SIGNED: J. J. Eglin

Groundwater Analyses for the 48-9G in the Lower Tulare Interval from 1,040 to 1,260 Feet

Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

CASE ENGINEERING AND LABORATORY.
"A" E. MAIN ST., VENTURA. 3003
(805) 653-1327

48-9g

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REPORT OF GEOCHEMICAL ANALYSIS

WILLIAMS BROTHERS ENGINEERING CO.
Well #48-9G Tulare Test
Sampled May 26, 1978 11:30 A.M.
Flowline Sample, Swab Sample

Att: George Elledge

RADICALS	Milligrams Per Liter	Reacting Value	Per Cent
Sodium; A.A.	2900	126.15	-
calc.	3040	132.24	40.82
Potassium	47.2	1.21	0.37
Ammonium	-	-	-
Calcium	375	18.71	5.78
Magnesium	121	9.95	3.07
Barium	TR<0.2	-	-
Iron (total)	0.5	-	-
Sulfate	1810	37.70	11.64
Chloride	4250	119.89	37.01
Hydroxide	0	0	0
Carbonate	0	0	0
Bicarbonate	247	4.05	1.25
Borate	24	0.31	0.10
Silica	11	-	-
* Organic Acids	-		
Salinity as Salt (NaCl)	-		
Total Solids	9926		

Specific Gravity @ 60° F.
Resistivity 70.3 ohm-cm @ 75° F.
pH Value 6.8

CHEMICAL CHARACTER

Primary Salinity	82.38	%
Secondary Salinity	14.92	%
Primary Alkalinity	0	%
Secondary Alkalinity	2.70	%

*Included in Bicarbonates

BK10409728

Groundwater Analyses for the 48-9G in the Lower Tulare Interval from 1,040 to 1,260 Feet

48-9g.

GEOCHEMICAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	7/31/78	WELL NO.	48-9G 390 BWPD Upper Zone
DATE OF SAMPLING	7/14/78	COMPANY	Williams Bros. Engineering Co.
SAMPLED BY		FIELD	
LABORATORY NO.	5862	ZONE	595 ft 935 ft Flowline Producing
ANALYST		SAMPLE SOURCE	

RADICALS		PARTS PER MILLION (MILLIGRAMS PER LITER)	REACTING VALUE (EQUIVALENTS PER MILLION)	REACTING VALUE (PERCENT)
SODIUM+Potassium	Na+K	2010.0	87.39	37.92
CALCIUM	Ca	310.	15.50	6.73
MAGNESIUM	Mg	150.	12.34	5.35
BARIUM	Ba	less than1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1895.	39.48	17.13
CHLORIDE	Cl	2584.9	73.02	31.68
CARBONATE	CO_3	-	-	-
BICARBONATE	HCO_3	166.3	2.73	1.19
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	52.0		
IRON, ALUMINA	R_2O_3			
TOTAL		7168.	230.5	100.00

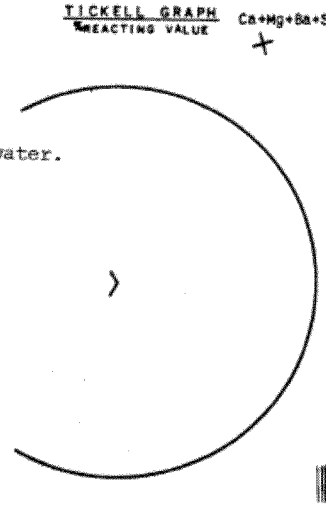
GROUP	CHEMICAL CHARACTER		MISCELLANEOUS		
ALKALIS	PRIMARY SALINITY	75.84	BORON	8.2	PPM
EARTHS	SECONDARY SALINITY	21.78	HYDROGEN SULFIDE	less than 0.1	ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	6050.2	PPM
WEAK ACIDS	SECONDARY ALKALINITY	2.38	RESISTIVITY @ 77°F	0.97	O.M.
Ca/EARTHS Mg = 1.26			CHLORINITY	4264.4	PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.008	
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.6	

REMARKS

Potassium, K = 17 ppm
Iron, Fe = 1.2 ppm

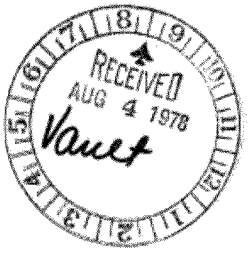
Note: The subject water contains 0.205 times the solids content of normal sea water.

TICKELL GRAPH (%REACTING VALUE)



ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

SIGNED: J. J. Eglin



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Groundwater Analyses for the 48-9G in the Lower Tulare Interval from 595 to 935 Feet

Attachment 15: Tulare Groundwater Analyses – 82-2B and 48-9G Wells

Attention Mr. Ge[illegible]e Elledge

48-9g

GEOCHEMICAL ANALYSIS OF WATER Pro-391

48-9G

DATE OF REPORT	8/16/78	WELL NO.	48-0G Flowline Upper Zone
DATE OF SAMPLING	7/14/78 2:15 pm	COMPANY	Williams Bros. Engineering Co.
SAMPLED BY		FIELD	
LABORATORY NO.	6018	ZONE	Tulare Sand
ANALYST		SAMPLE SOURCE	

RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM+Potassium	Na+K	2111.2	91.79	38.15
CALCIUM	Ca	340.	17.0	7.07
MAGNESIUM	Mg	140.	11.51	4.78
BARIUM	Ba	less than1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1880.	39.16	16.28
CHLORIDE	Cl	2775.7	78.41	32.59
CARBONATE	CO_3	0	0	0
BICARBONATE	HCO_3	166.3	2.73	1.13
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	40.		
IRON, ALUMINA	R_2O_3			
TOTAL		7453.	240.6	100.00

GROUP	CHEMICAL CHARACTER		MISCELLANEOUS	
ALKALIS	PRIMARY SALINITY	76.30	BORON	9.4 PPM
EARTHS	SECONDARY SALINITY	21.44	HYDROGEN SULFIDE	less than 0.1 ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	6050 PPM
WEAK ACIDS	SECONDARY ALKALINITY	2.26	RESISTIVITY @ 77°F	0.97 O.M.
Ca/[illegible] Mg = 1.48			CHLORINITY	4579 PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.020
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.2

REMARKS

TICKELL GRAPH % REACTING VALUE

Na+K

Ca+Mg+Ba+Sr

Potassium, K = 19 ppm
Iron, Fe = 0.12 ppm

Note: The subject water contains 0.213 times the solids content of "normal sea water".

BK10409730
OEHI

MATERIAL & SERVICE RELEASE/RECEIVING

PRODUCTION WELL NO. 48-9G

DRILLING WELL NO.

M E J NO.

OTHER

I certify that all indicated services have been performed and/or all materials received.

By [signature] Date 8/22/78

CO_3 HCO_3 OH

RECEIVED AUG 24 1978 Vaust

BC Laboratories

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BAKERSFIELD, CA 93308
(805) 325-7478

Cl+I+Br

SO_4

ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

SIGNED: [signature]

Groundwater Analyses for the 48-9G in the Lower Tulare Interval from 595 to 935 Feet

Attachment 16: Methodology of Groundwater Sample Obtained from the 82-2B

This well was chosen due to being idle because of poor production rates in the shallow oil zone (Etchegoin formation), located where water was suspected to be present in the Tulare formation, and in an area where Oxy would like to drill and stimulate new wells.

Step 1) Plugged well back by setting a Bridge Plug at 2603 feet below ground surface (bgs). Confirmed that isolation of the wellbore from the previous hydrocarbon completion had been achieved by, pressure testing the plug and casing to 500 pounds per square inch gauge (psig).

Step 2) Circulated two full wellbore volumes of fresh water down tubing and up casing to remove produced fluids. The source of the fresh water used was from West Kern Water District.

Step 3) Ran Cement Bond Log to verify isolation of Tulare behind casing. Bond log indicated good isolation above and below target perforations.

Step 4) Evacuated the wellbore of fluid by, pumping air down the tubing and up the casing. A total of 100 barrels of fresh water was recovered from the wellbore. The wellbore calculated capacity was 105 barrels.

Step 5) The tubing was removed and the Tulare zone was perforated from 996 feet to 1036 feet.

Step 6) Ran tubing back in the well to 1600 feet bgs and pumped Nitrogen through tubing in an attempt to clear any new fluids that had entered the wellbore from the Tulare zone.

Step 7) Ran second Bridge Plug and set at 1090 feet bgs and packer at 980 feet bgs, isolating perforations (996-1036).

Step 8) Drew Tulare fluids into wellbore using swab equipment. Swab equipment consists of rubber cups on a wireline that are run down the tubing and then pulled back to surface reducing the pressure in the wellbore to allow fluids to enter the well through Tulare perforations and up to surface.

Step 9) A water sample from fluids being brought to surface with the swab equipment was captured. The third party company, BC Labs, handled acquiring the sample at the well site to do GeoChem analysis of sample.

Step 10) Eight one liter amber glass containers with Teflon lined lids were used to collect samples for analytical testing. Upon collection, Electrical Conductivity (EC), temperature and pH measurements were taken in the field and showed to be stable.

Step 11) Sample containers were labeled and immediately placed on ice and delivered to laboratory for additional preservation and splitting.

Step 12) A chain of custody form was completed and the samples were transported by a BC Lab representative from Elk Hills to BC Labs in Bakersfield California for analysis.

Attachment 17: Porosities and Permeabilities of Sands in the Lower Tulare

Core from 1CH-27R
Horizontal Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
665	7,447	39.1	sand	LT
713	7,343	37.9	sand	LT
773	4,093	40.8	sand	LT
837	2,511	37.7	sand	LT
877	1,678	37.4	sand	LT
899		33.3	sand	LT
913	2,844	34.9	sand	LT
918		38.3	sand	LT
974.5		33.4	sand	LT
982		36.2	sand	LT
988		37.0	sand	LT
Average:	**4,319**	**36.9**		

Core from 1CH-27R
Vertical Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
679	3,505.8	40.6	sand	LT
725.1	20.7		sand	LT
774	2,413.2	37.3	sand	LT
850	1,630.5		sand	LT
856	489.2	35.9	sand	LT
920.4	1,351.2		sand	LT
Average:	**1,568**	**37.9**		

Core from 46WD-7G
Horizontal Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
694.5	307.0	36.3	sand	LT
696.5	448.3	30.1	sand	LT
697.5	17.8	36.2	sand	LT
698.5	187.5	35.8	sand	LT
699.5	3,198.6	33.6	sand	LT
700.5	2,045.4	35.5	sand	LT
701.5	3,183.6	34.2	sand	LT
702.5	2,604.8	32.7	sand	LT
713.5	369.7	36.6	sand	LT
714.5	888.2	34.5	sand	LT
719.5	60.4	32.7	sand	LT
720.5	133.4	36	sand	LT
727.5	1,861.0	32.5	sand	LT
728.5	1,613.4	38.4	sand	LT
730.5	859.1	31.4	sand	LT
731.5	478.7	30	sand	LT
732.5	2,223.6	35.7	sand	LT
733.5	5,848.9	37.2	sand	LT
734.5	4,622.1	35.8	sand	LT
740.5	44.0	33.8	sand	LT
741.5	749.2	38	sand	LT
742.5	108.0	31.2	sand	LT
Average:	**1,447.9**	**34.5**		

Attachment 17: Porosities and Permeabilities of Sands in the Lower Tulare

Core from 36-30R Horizontal Permeability/Porosity				
Depth	Permeability (md)	Porosity (%)	Lithology	Unit
1,170.05	2,090	37.2	sand	LT
1,171.05	256	39.1	sand	LT
1,172.05	4,320	34.4	sand	LT
1,173.05	1,450	39.4	sand	LT
1,174.10	572	37.7	sand	LT
1,175.05	1,030	33.7	sand	LT
1,180.05	59	31.9	sand	LT
1,183.05	3,080	24.2	sand	LT
1,184.05	3,200	35.8	sand	LT
1,185.10	1,980	38.7	sand	LT
1,186.20	1,840	39.3	sand	LT
1,187.25	2,040	40.4	sand	LT
1,188.80	152	30.8	sand	LT
1,189.70	328	38.3	sand	LT
1,190.75	1,770	38.1	sand	LT
1,205.80	7.7	33.8	sand	LT
Average:	**1,510.9**	**35.8**		
Average:	**1,862**	**35.4**		

HISTORICAL RECORD:

OCCIDENTAL OF ELK HILLS, INC.
35R LABORATORY SERVICES

GEOCHEMICAL WATER ANALYSIS

Log Number:	GEO960042	Collected by:	
Sample Date:	05/02/96	Requested by:	
Sample Location:	476-27R	Reported by:	
Sample Source:	Test Separator		

CONSTITUENTS		mg/l	meq	% meq	METHODS	NOTES
CATIONS						
Sodium	Na	3498.00	152.09	40.63	AA	
Potassium	K	40.96	1.05	0.28	AA	
Calcium	Ca	330.80	16.51	4.41	AA	
Magnesium	Mg	212.20	17.45	4.66	AA	
Barium	Ba	0.47	0.01	0.00	AA	
Strontium	Sr	2.90	0.07	0.02	AA	
Iron	Fe	2.50			AA	
Silicon	Si	34.73			AA	
Boron	B	8.87			AA	
ANIONS						
Chloride	Cl	5600.00	157.97	41.60	Titration	
Bicarbonate	HCO3	1000.40	16.40	4.32	Titration	
Carbonate	CO3	0.00	0.00	0.00	Titration	
Hydroxide	OH	0.00	0.00	0.00	Titration	
Sulfate	SO4	2.00	15.52	4.09	Turbidity	
Silica	SiO2	74.32			Calculation	
Borate	BO3	48.25			Calculation	
Phosphate	PO4	0.12			Colorimetry	

pH	7.4
Specific Gravity (60°F)	1.010
Ca(meq) / Mg (meq)	0.95
Hardness (mg CaCO3)	1697
TDS1 (From SG, mg/l)	13700
TDS2 (Sum of IONs, mg/l)	11562
Sum of Cations (meq/l)	187
Sum of Anions (meq/l)	190
% Diff. of Cations & Anions	-1.5
Sample Temperature (°F)	n/a
Resistivity (25°C, Ohm-m)	n/a
Conductivity (25°C, µmho/cm)	n/a

PALMER VALUES:	(%)
Primary Salinity:	81.82
Secondary Salinity:	9.55
Tertiary Salinity:	0.00
Primary Alkalinity:	0.00
Secondary Alkalinity:	8.63
Stability Index (Stiff-Davis) *:	
SI=0, Water is Stable @ (F) *:	0
Saturation Index (Langelier) **	0.00
Dissolved Oxygen (mg/l):	0.0
Carbon Dioxide (mg/l):	0.0
Total Sulfides as H2S (mg/l):	0.0

SG: Specific Gravity
TDS: Total Dissolved Solid
TDS1: n/a for Fresh Water (<1600 mg/l)

If Sample Temp is "n/a", SIs calculated @77°F
* : CaCO3, Brine Water System
**: CaCO3, Fresh Water System

REMARKS:

0
0
0

Geochem_DTA

Printed: 4/20/2015

HISTORICAL RECORD:

OCCIDENTAL OF ELK HILLS, INC.
35R LABORATORY SERVICES

GEOCHEMICAL WATER ANALYSIS

Log Number:	GEO930219	Collected by:	
Sample Date:	11/23/93	Requested by:	
Sample Location:	474-32S	Reported by:	
Sample Source:	DGZ WELL		

CONSTITUENTS		mg/l	meq	% meq	METHODS	NOTES
CATIONS						
Sodium	Na	7980.00	346.96	44.38	AA	
Potassium	K	50.20	1.28	0.16	AA	
Calcium	Ca	539.60	26.93	3.44	AA	
Magnesium	Mg	188.60	15.51	1.98	AA	
Barium	Ba	1.16	0.02	0.00	AA	
Strontium	Sr	8.02	0.18	0.02	AA	
Iron	Fe	1181.00			AA	
Silicon	Si	33.30			AA	
Boron	B	14.50			AA	
ANIONS						
Chloride	Cl	14000.00	394.92	49.22	Titration	
Bicarbonate	HCO3	47.58	0.78	0.10	Titration	
Carbonate	CO3	0.00	0.00	0.00	Titration	
Hydroxide	OH	0.00	0.00	0.00	Titration	
Sulfate	SO4	0.28	5.45	0.68	Turbidity	
Silica	SiO2	71.26			Calculation	
Borate	BO3	78.88			Calculation	
Phosphate	PO4	0.39			Colorimetry	

pH	5.3
Specific Gravity (60°F)	1.019
Ca(meq) / Mg (meq)	1.74
Hardness (mg CaCO3)	2122
TDS1 (From SG, mg/l)	n/a
TDS2 (Sum of IONs, mg/l)	24427
Sum of Cations (meq/l)	391
Sum of Anions (meq/l)	401
% Diff. of Cations & Anions	-2.6
Sample Temperature (°F)	n/a
Resistivity (25°C, Ohm-m)	n/a
Conductivity (25°C, µmho/cm)	n/a

PALMER VALUES:	(%)
Primary Salinity:	89.09
Secondary Salinity:	10.71
Tertiary Salinity:	0.00
Primary Alkalinity:	0.00
Secondary Alkalinity:	0.19
Stability Index (Stiff-Davis) *:	
SI=0, Water is Stable @ (F) *:	0
Saturation Index (Langelier) **	0.00
Dissolved Oxygen (mg/l):	0.0
Carbon Dioxide (mg/l):	0.0
Total Sulfides as H2S (mg/l):	0.0

SG: Specific Gravity
TDS: Total Dissolved Solid
TDS1: n/a for Fresh Water (<1600 mg/l)

If Sample Temp is "n/a",SIs calculated @77°F
* : CaCO3, Brine Water System
**: CaCO3, Fresh Water System

REMARKS:

0
0
0

Geochem_DTA Printed: 4/20/2015

Attachment 19: State Water Resources Control Board Concurrence with Determination of Absence of Protected Water in Section 36, T30S/R23E

CALIFORNIA Water Boards

EDMUND G. BROWN JR.
GOVERNOR

MATTHEW RODRIQUEZ
SECRETARY FOR ENVIRONMENTAL PROTECTION

State Water Resources Control Board

SEP 16 2014

Mr. Stephen Anthony Reid
Occidental of Elk Hills, Inc.
P.O. Box 1001, 28590 Highway 119
Tupman, CA 93276

RE: WRITTEN CONCURRENCE – GROUNDWATER MONITORING PLAN EXEMPTION, ELK HILLS OIL FIELD, SECTION 36R, TOWNSHIP 30 SOUTH, RANGE 23 EAST

Dear Mr. Reid:

This letter is in response to your *Request for Written Concurrence – Absence of Protected Waters and Groundwater Monitoring Exemption, Revised to Address Location of Water Wells, Elk Hills Oil Field (Section 36R, Township 30 South, Range 23 East) Kern County, California* dated September 10, 2014. As outlined in the submittal, Occidental of Elk Hills, Inc. (OEHI) is requesting an exemption from the requirement to submit a groundwater monitoring plan for proposed well stimulations treatment(s) (WST) within the subject area.

The Division of Oil, Gas, and Geothermal Resources' Interim Well Stimulation Regulations allow well operators to seek written concurrence from the State Water Resources Control Board where the operator can demonstrate the absence of protected water as the basis for not conducting groundwater monitoring (Cal. Code Regs. title 14, § 1783.4).

The OEHI submittal was signed by a California professional geologist and included a soil boring log, well geophysical logs, detailed geologic cross-sections clearly depicting geologic units and the hydrocarbon zone, and detailed analysis estimating total dissolved solid concentrations using electronic log data. Your submittal indicated the absence of protected water within the section, as shown in the attached figure (enclosure 1).

Based upon our review of your submittal, we hereby concur with your determination. If information in the future indicates the presence of protected waters, the Water Boards will once again review this determination.

If you have any questions pertaining to this issue, please contact Ms. Janice Zinky at (916) 341-5897.

Sincerely,

Jonathan Bishop
Chief Deputy Director
State Water Resources Control Board

Attachment 19: State Water Resources Control Board Concurrence with Determination of Absence of Protected Water in Section 36, T30S/R23E

Enclosure 1

cc: w/ enclosure

Clay Rodgers, Assistant Executive Officer,
Central Valley Region (R5), (via electronic
copy and First class mail)

Vincent Agusiegbe, SB4 Program Manager
Division of Oil, Gas & Geothermal
Resources (via electronic copy and First
class mail)

Attachment 20: Porosities and Permeabilities of Clays and Silts in the Amnicola Claystone and Lower Tulare

Core from 1CH-27R
Horizontal Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
938		26.8	slt	LT
951		26.1	slt	LT
960		24.9	clay	LT
969		26.9	clay	LT
998	23.6	38.6	clay	LT
Average:	**23.6**	**28.7**		

Core from 1CH-27R
Vertical Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
605	<0.1		clay	AM
694.1	<0.1		slt	LT
750	0.1		slt	LT
820	1		clay	LT
893.3	<0.1		clay	LT
940.8	1		slt	LT
963	<0.1		slt	LT
Range:	**<0.1 to 1.0**			

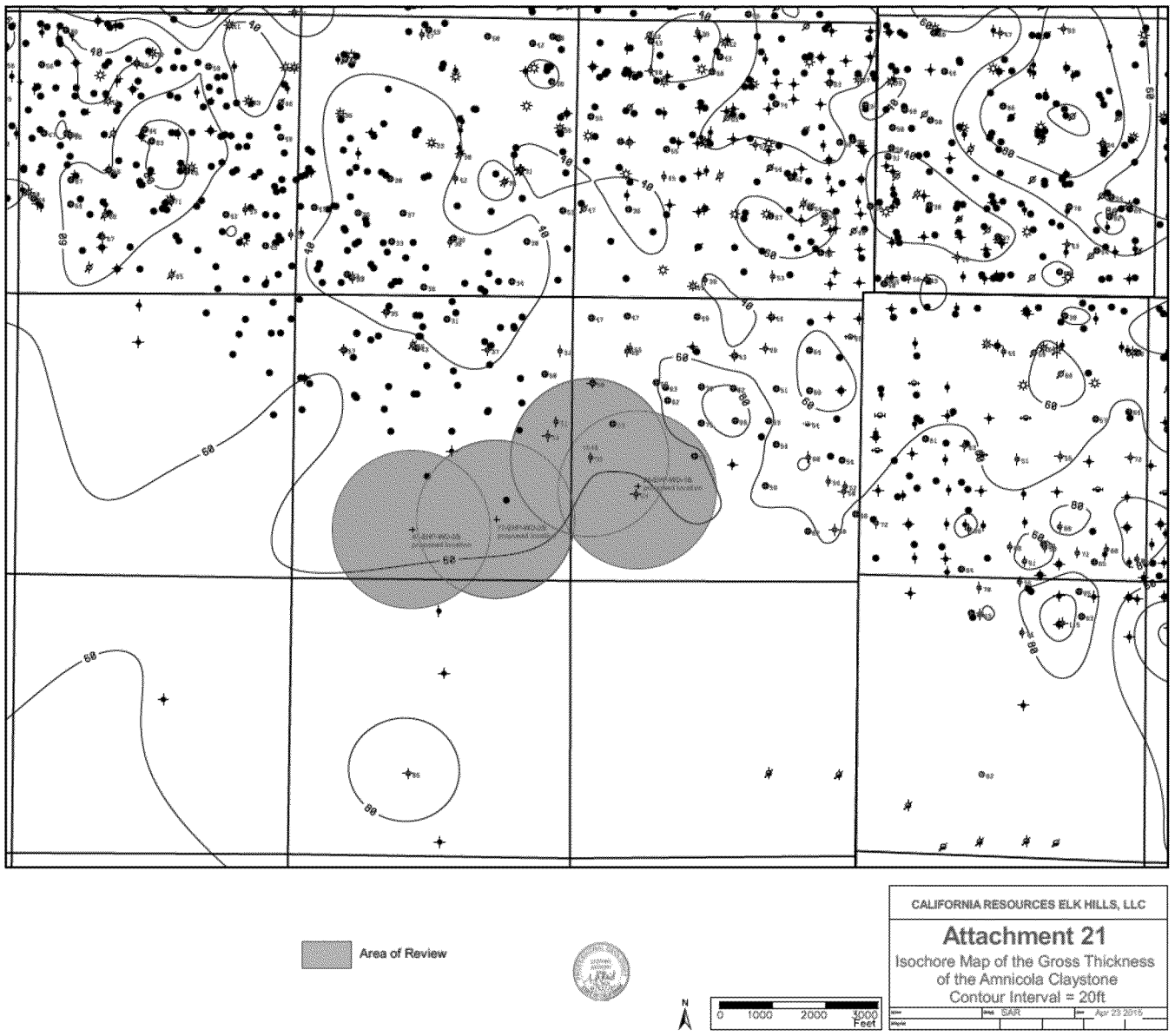
Core from 46WD-7G
Horizontal Permeability/Porosity

Depth	Permeability (md)	Porosity (%)	Lithology	Unit
687.5	2.8	13.7	silt	LT
688.5	63.8	34.1	clay	LT
690.5	60.5	34.3	clay	LT
691.5	32.7	32.4	clay	LT
692.5	26	15.1	silt	LT
693.5	20	32.9	silt	LT
712.5	36.5	37	clay	LT
735.5	16.6	37.8	clay	LT
743.5	3.3	33.4	clay	LT
Average:	**29.1**	**30.1**		
Minimum:	**2.8**	**13.7**		
Maximum:	**63.8**	**38.6**		

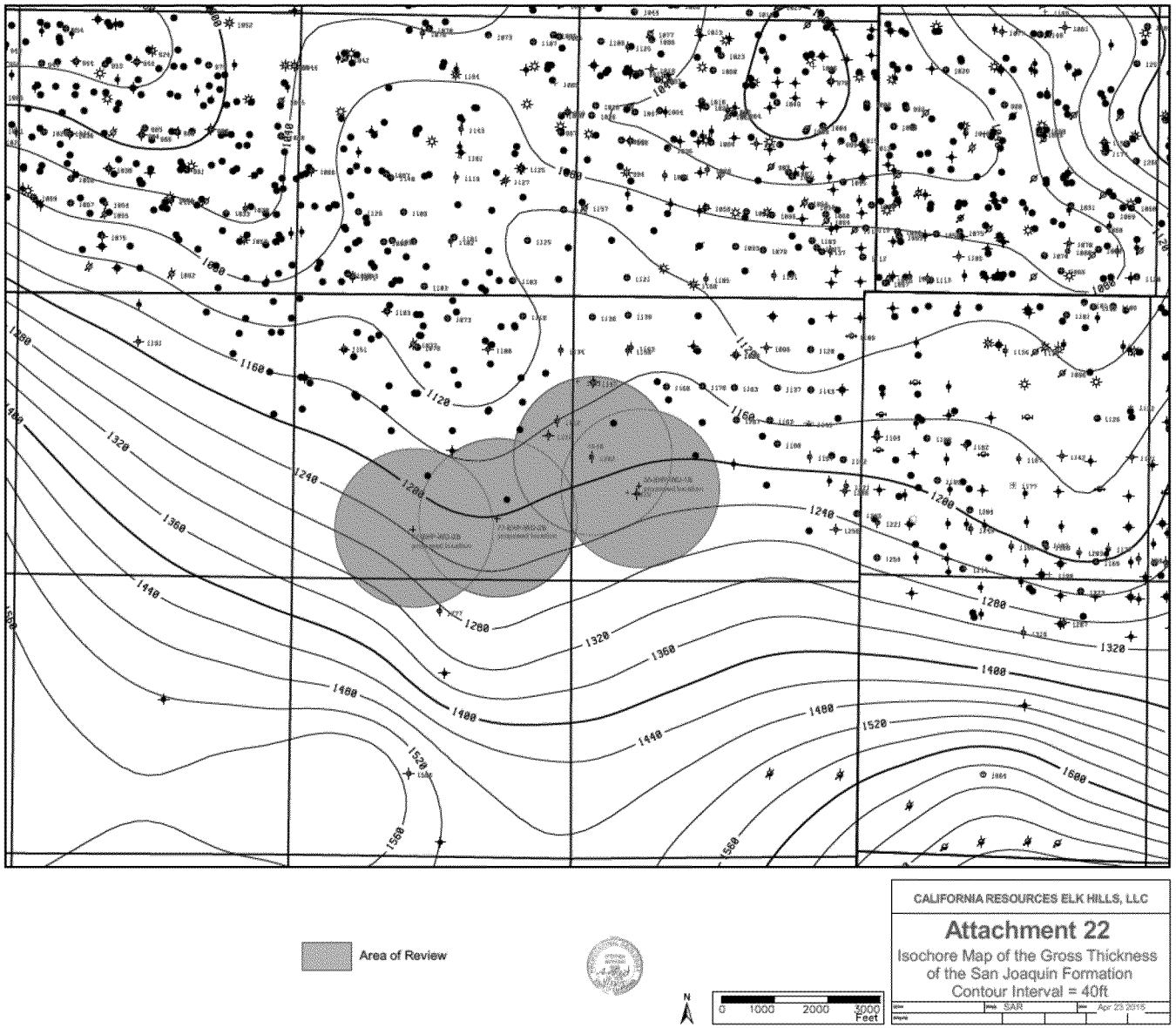
LT = Lower Tulare

AM = Amnicola Claystone

Attachment 21: Isochore Map of the Gross Thickness of the Amnicola Claystone



Attachment 22: Isochore Map of the Gross Thickness of the San Joaquin Formation



Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities

Calculation of salinity is a four step process: (1) converting measured density to formation porosity, (2) calculation of apparent water resistivity using the Humble equation, (3) correcting apparent water resistivity to a standard temperature, and (4) converting temperature corrected apparent water resistivity to salinity.

For step 1, the equation to convert measured density to porosity is:

POR = (Rhom - RHOB) /(Rhom-Rhof)

Parameter definitions for the equation are:

POR is formation porosity
Rhom is formation matrix density (g/cc); 2.65 g/cc is used for sandstones
RHOB is calibrated bulk density taken from well log measurements (g/cc)
Rhof is fluid density (g/cc); 1.00 g/cc is used for water-filled porosity

For step 2, the Humble equation calculates apparent water resistivity. The equation as described by Davis (1988) is:

Rwah = ((PORm) * XRESD)/a**

Parameter definitions for the equation are:

Rwah is apparent water resistivity (ohmm)
POR is formation porosity as derived from the density conversion formula
m is the cementation factor; 2.15 is the standard value used in the Humble equation
XRESD is deep reading formation resistivity taken from well log measurements (ohmm)
a is the Archie constant; 0.62 is the standard value used in the Humble equation

For step 3, Humble apparent water resistivity is corrected from formation temperature to a surface temperature standard of 75°F:

Rwahc = Rwah * ((TEMP)+6.77)/(75+6.77)

Parameter definitions for the equation are:

Rwahc is apparent water resistivity (ohmm), corrected to surface temperature
TEMP is downhole temperature based on temperature gradient (°F)

Step 4 is the conversion of corrected apparent water resistivity to salinity. There are two ways to accomplish this: either by using a nomograph from a standard industry chart book (Schlumberger, 1978, Chartbook GEN-9). A formula may also be used for the conversion (from Baker Hughes, 2002, introduction to Wireline Log Analysis, p. 111):

Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities

SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)

Parameter definitions for the equation are:

SAL_h is salinity from corrected Rwahc (ppm)
Rwahc is apparent water resistivity, corrected to surface temperature (ohmm), calculated above

As a demonstration of the four-step calculation process, salinity for Sand 86E-2 is calculated at 1020 feet (md) in well 86E-34R. For the calculations, input parameters from the wellbore logs are:

RHOB = 2.184 g/cc
TEMP = 90.4°F
XRESD = 2.136 ohmm

For step 1, the equation to convert measured density to porosity is:

POR = (Rhom - RHOB) /(Rhom-Rhof)

POR = (2.65 - RHOB) /(2.65 - 1.0)
= (2.65 - 2.184)/(2.65 - 1.0)
= 0.2824
= 28.2% porosity

For step 2, the Humble equation calculates apparent water resistivity:

Rwah = ((POR**m) * XRESD)/a

Rwah = ((POR**2.15) * XRESD)/0.62
= ((0.2824**2.15) * 2.136)/0.62
= 0.227 ohmm @ 90.4°F

For step 3, Humble apparent water resistivity is corrected from formation temperature to a surface temperature standard:

Rwahc = Rwah * ((TEMP)+6.77)/(75+6.77)

Rwahc = Rwah * (TEMP)+6.77)/(75+6.77)
= 0.227 * (90.4 +6.77)/(75+6.77)
= 0.269 ohmm @ 75°F

Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities

For step 4, the formula method is used for the conversion of corrected apparent water resistivity to salinity.

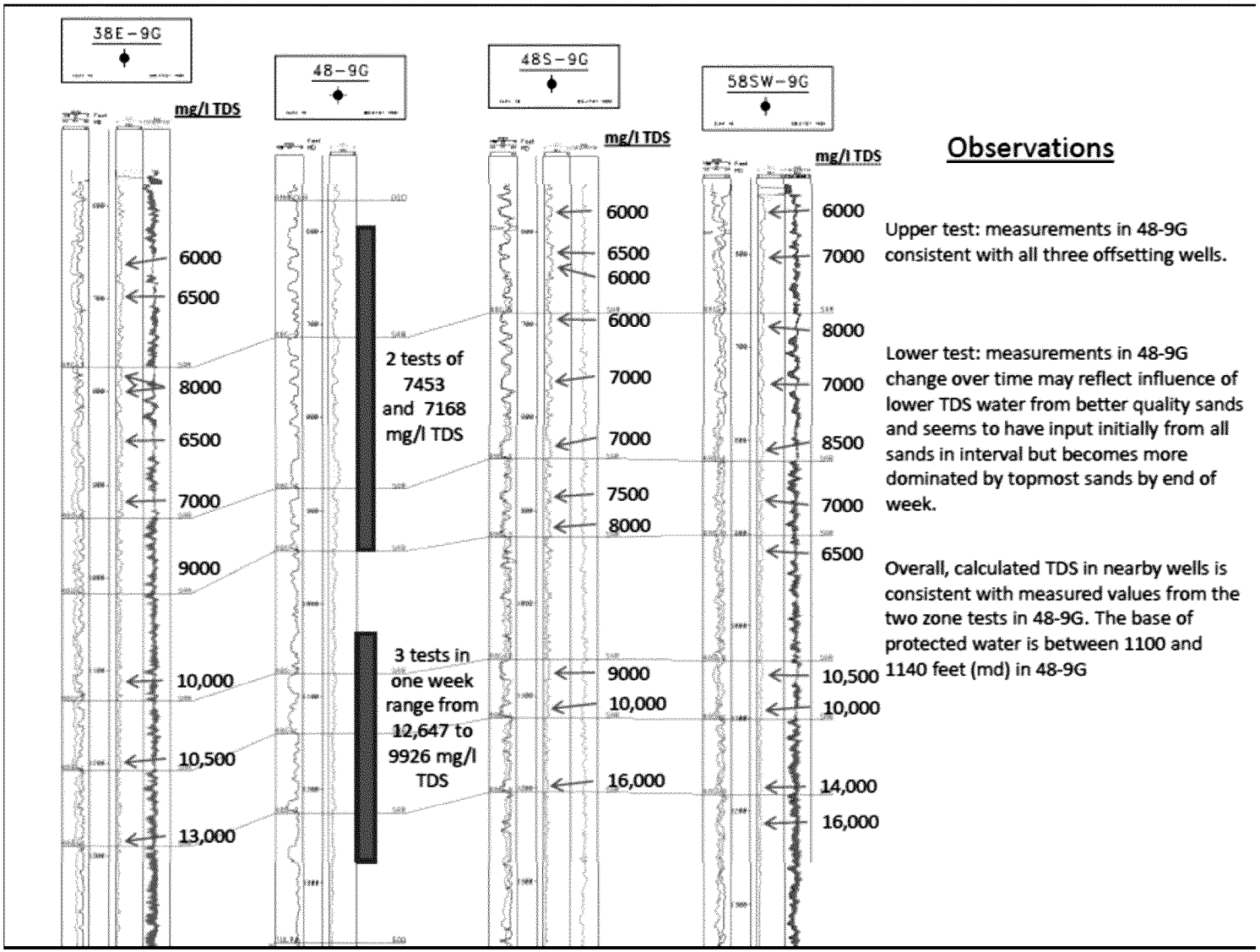
SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)

SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)
= 10 ** ((3.562-(Log10(.269-0.0123)))/.955)
= 10 ** ((3.562+.5905)/.955)
= 22,300 ppm TDS

The nomograph is also used to estimate salinity from corrected apparent water resistivity and temperature. At the depth of 1020 feet (md) in well 86E-34R, the nomograph salinity value is between 23 and 24 kppm, or between 23,000 and 24,000 ppm.

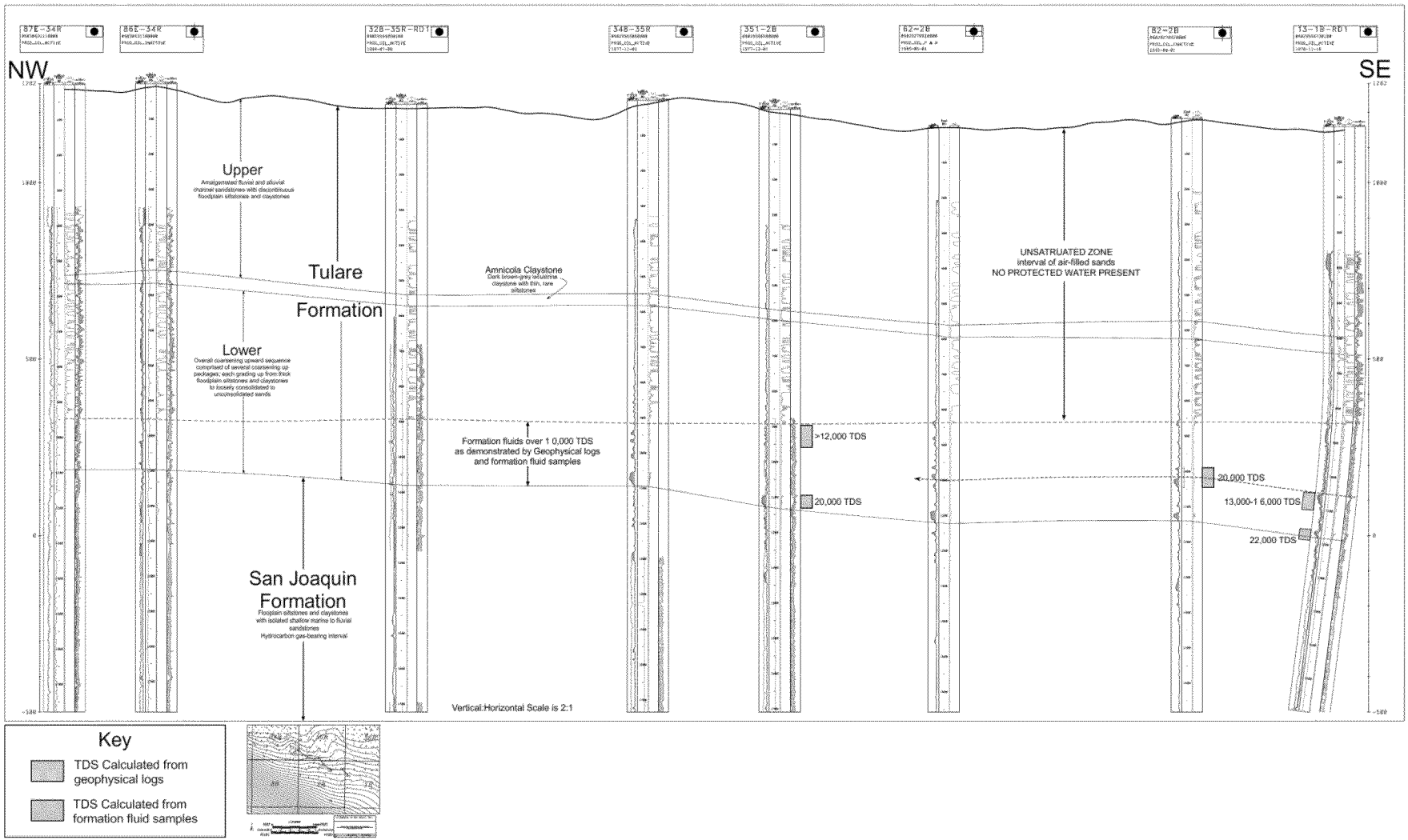
Note: Discussion of salinity calculation method and all geologic work in this attachment was prepared by Mr. Stephen A. Reid of OEHI, California-licensed Professional Geologist No. 3876.

Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities



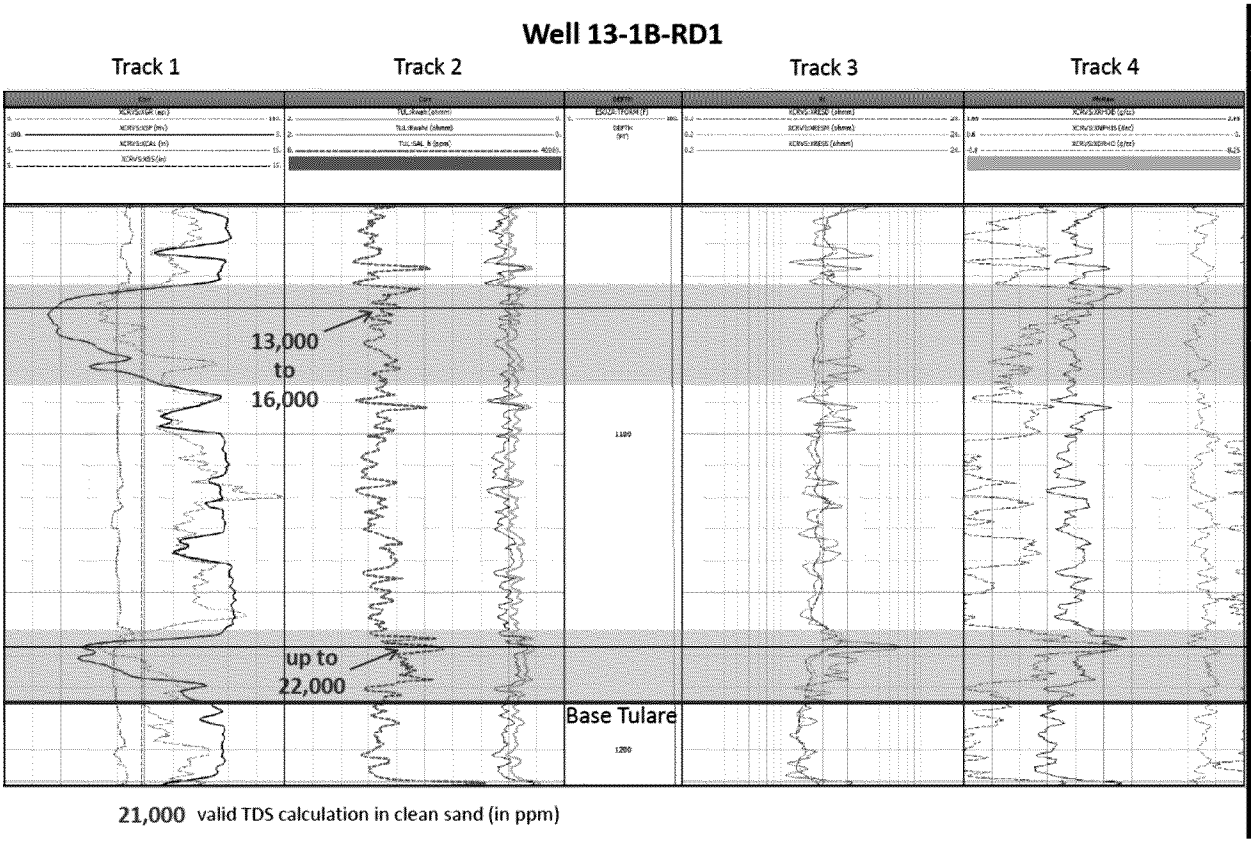
Comparison of Measured and Calculated Salinities in the Lower Tulare in the 9G Area

Attachment 23: Salinity Calculation Method and Comparison of Measured and Calculated Salinities

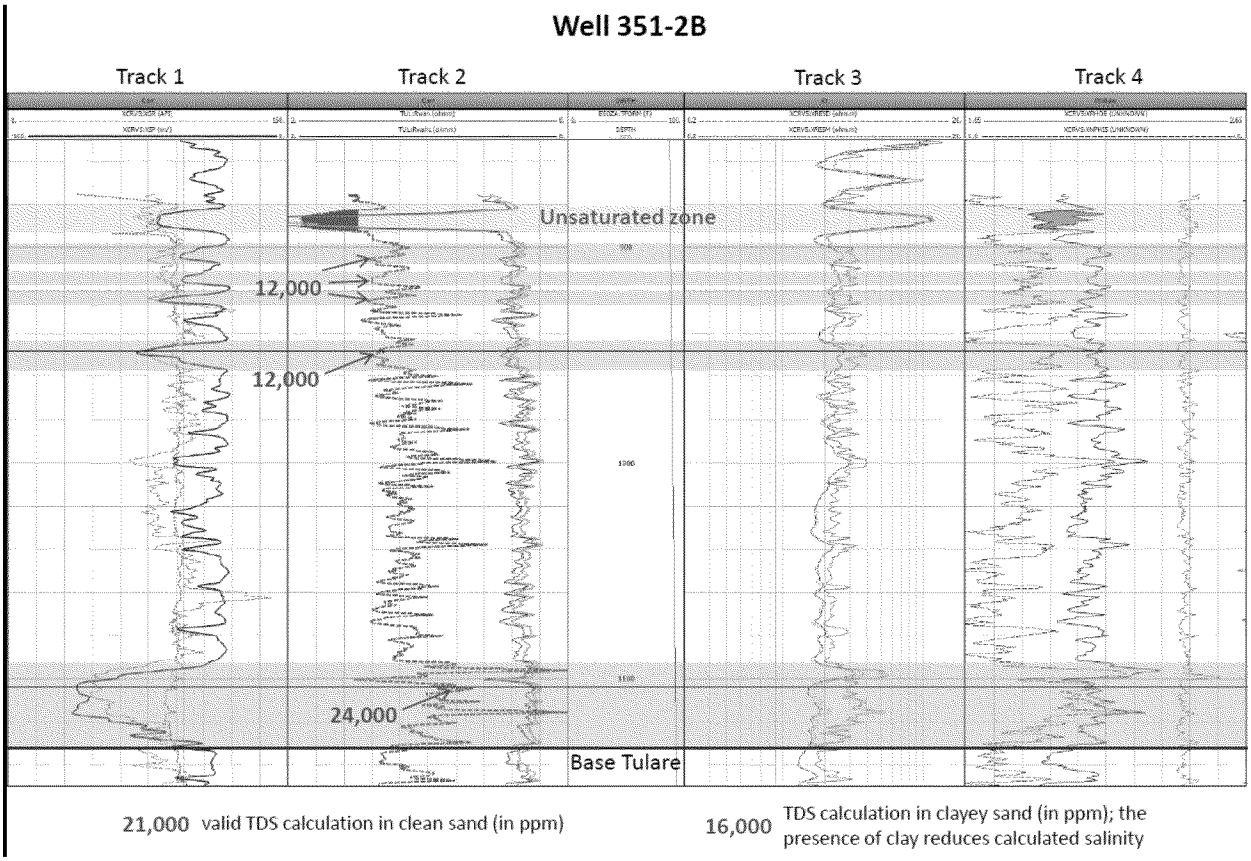


Comparison of Measured and Calculated Salinities in the Lower Tulare in the 34R and 1B Areas

Attachment 24: Salinity Calculations in the 13-1B-RD1



Attachment 25: Salinity Calculations in the 351-2B



Attachment 26: Summary of Current and Future Water Demand for the West Kern Water District

TABLE 2-19
SUMMARY OF URBAN WATER DEMAND (AFY)

Subregion	Purveyor	Demand 2005	2010	2015	2020	2025	2030	Notes
Greater Bakersfield	KCWA Improvement District No.4							
	California Water Service	12,500	11,500	19,500	20,500	20,500	20,500	(a)
	City of Bakersfield	6,500	0	6,500	6,500	6,500	6,500	(a)
	East Niles CSD	6,000	5,000	11,000	11,000	11,000	11,000	(a)
	North of the River MWD	2,200	8,500	11,000	11,500	12,500	13,750	(a)
	Oildale MWC	7,800	8,528	9,323	10,193	11,144	12,184	(b)
	City of Bakersfield (demand besides ID4)	26,179	25,168	27,764	32,590	38,778	45,331	(c)
	Casa Loma Water Company	--						
	Greenfield CWD	2,600	2,843	3,108	3,398	3,715	4,061	(b)
	Stockdale MWC and Annex	200	219	239	261	286	312	(b)
	Victory MWC	205	224	245	268	293	320	(b)
	Subtotal	***64,184***	***61,982***	***88,679***	***96,210***	***104,716***	***113,958***	
Kern Fan	Buttonwillow CWD	130	142	155	170	186	203	(b)
	Vaughn WC	10,700	13,200	15,400	17,600	19,600	21,827	(d)
	West Kern WD	24,681	24,729	26,983	27,080	27,177	27,275	(e)
	Subtotal	***35,511***	***38071***	***42,538***	***44,850***	***46,963***	***49,305***	
	Tehachapi-Cummings CWD	6,712	7,338	8,023	8,771	9,590	10,484	(f)

Notes:
(a) ID4. 2010 UWMP
(b) Year 2005 from unpublished KCWA data. Water demands 2005 to 2030 assumed to grow 1.8% per year based on Kern Council of Governments Draft Regional Forecast Report.
(c) Demand reported in City of Bakersfield 2005 UWMP less demand reported for City in ID4 2005 UWMP.
(d) Vaughn WC 2005 UWMP. Data for 2030 estimated based on growth rate 2020 to 2025.
(e) West Kern WD 2010 UWMP.
(f) Data for 2005 M&I demands provided by Tehachapi-Cummings CWD. Water demands assumed to grow 1.8% per year, based on Kern Council of Governments Draft Regional Forecast

Urban water demand in the WKWD, which was estimated to be 5.5% from 2010-2030, was the lowest of the water districts in the Kern Fan Subregion. Excerpt of Table 2-19 (Kern County Water Agency, 2011)

Attachment 26: Summary of Current and Future Water Demand for the West Kern Water District

TABLE 4-1
SUMMARY OF ESTIMATED CURRENT AND FUTURE WATER DEMAND BY WATER USE CATEGORY FOR THE KERN FAN SUBREGION

	2005			2030		
Purveyor	M&I	AG[d]	TOTAL	M&I	AG[d]	TOTAL
Buena Vista WSD	--	108,052	108,052	--	108,052	108,052
Buttonwillow CWD	130[a]	--	130	130[a]	--	130
Buttonwillow ID	--	178,802	178,802	--	178,802	178,802
Henry Miller WD	--	47,178	47,178	--	47,178	47,178
Kern Water Bank Authority	--	--	--	--	--	0
City of Maricopa (see West Kern WD)	--	--	--	--	--	0
Rosedale-Rio Bravo WSD	--	81,449	81,449	--	81,449	81,449
City of Taft (see West Kern WD)	--	--	--	--	--	0
Vaughn WC	10,700[b]	--	10,700	21,827[b]	--	21,827
West Kern WD	24,681[c]	--	24,681	27,275[c]	--	27,275
Total	**35,511**	**415,481**	**450,992**	**49,232**	**415,481**	**464,713**

Notes:
(e) Year 2005 from unpublished KCWA data. Water demands 2005 to 2030 assumed to grow 1.8 percent per year based on Kern Council of Governments Draft Regional Forecast Report.
(f) Vaughn WC 2005 UWMP. Data for 2030 estimated based on growth rate 2020 to 2025.
(g) West Kern WD 2010 UWMP.
(h) Unpublished KCWA data. 2005 agricultural demand data based on 2007 summary by Crop Group. 2030 agriculture demand data based on equivalent production as 2005 data.

Note: M&I = Municipal and industrial demand

Attachment 26: Summary of Current and Future Water Demand for the West Kern Water District

TABLE 2-19
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Subregion	Purveyor	Demand 2005	2010	2015	2020	2025	2030	Notes
Greater Bakersfield	KCWA Improvement District No.4							
	California Water Service	12,500	11,500	19,500	20,500	20,500	20,500	(a)
	City of Bakersfield	6,500	0	6,500	6,500	6,500	6,500	(a)
	East Niles CSD	6,000	5,000	11,000	11,000	11,000	11,000	(a)
	North of the River MWD	2,200	8,500	11,000	11,500	12,500	13,750	(a)
	Oildale MWC	7,800	8,528	9,323	10,193	11,144	12,184	(b)
	City of Bakersfield (demand besides ID4)	26,179	25,168	27,764	32,590	38,778	45,331	(c)
	Casa Loma Water Company	--						
	Greenfield CWD	2,600	2,843	3,108	3,398	3,715	4,061	(b)
	Stockdale MWC and Annex	200	219	239	261	286	312	(b)
	Victory MWC	205	224	245	268	293	320	(b)
	Subtotal	***64,184***	***61,982***	***88,679***	***96,210***	***104,716***	***113,958***	
Kern Fan	Buttonwillow CWD	130	142	155	170	186	203	(b)
	Vaughn WC	10,700	13,200	15,400	17,600	19,600	21,827	(d)
	West Kern WD	24,681	24,729	26,983	27,080	27,177	27,275	(e)
	Subtotal	***35,511***	***38071***	***42,538***	***44,850***	***46,963***	***49,305***	
Mountains/ Foothills	Tehachapi-Cummings CWD	6,712	7,338	8,023	8,771	9,590	10,484	(f)
	City of Tehachapi (in TCCWD)							
	Golden Hills CSD (in TCCWD)							
	Stallion Springs CSD2 (in TCCWD)							
	Bear Valley CSD (in TCCWD)							
	Long Canyon WC		-	-	-	-	-	(m)
	Frazier Park PUD	850	1,768	1,768	1,768	1,768	1,768	(g)
	Lebec CWD		-	-	-	-	-	(m)
	Tejon-Castac WD	176	1,587	3,126	4,809	6,521	8,842	(h)
	Subtotal	***7,738***	***10,693***	***12,917***	***15,348***	***17,879***	***21,094***	
Kern River Valley	California Water Service-KRVD	1,120	878	1,112	1,122	1,146	1,171	(i)
	Mt. Mesa WC		-	-	-	-	-	(m)
	Rainbird Valley MUC		-	-	-	-	-	(m)

Urban water demand for the WKWD is estimated to increase by 2,546 Acre-feet/year or about 5.5% annually between 2010 and 2030.